ANNALS

OF

The Entomological Society of America

Volume XVIII DECEMBER, 1925 Number 4

OBSERVATIONS ON THE RESPONSE OF ADULTS OF THE EUROPEAN CORN BORER TO LIGHT IN EGG LAYING.

By Geo. W. Barber

Cereal and Forage Insect Investigations, Bureau of Entomology, United States Department of Agriculture.

In its active stages as adult and larva the European corn borer (*Pyrausta nubilalis* Hubn.) is, for the most part, a lover of darkness. As dusk approaches during the periods of the year when the moths are in the field, they become active, fly, mate and deposit eggs during the hours of darkness and as dawn approaches they become inactive and rest or hide on the under side of leaves or in other protected places, remaining quiet during the day to resume activity when darkness approaches again. The larva, because of its habit of feeding in tunnels within the host plant throughout development, except in some instances during the first and second instar, is also negatively phototropic. Any migration of the larvae that may take place or any movement of larvæ outside of the burrow that may occur, happens principally at night, and while large numbers of larvæ may be found moving about outside their burrows at favorable times during the hours of darkness, they are seldom seen in daylight. On hatching from the egg, however, the young larvæ frequently wander about on the plant, feed on the epidermis of the leaves or bore into the leaves or midribs of leaves and feed for a time before entering the main stalk of corn or other food plant. This is especially the case in the spring when the food plants are small and even the main

stalks frequently being too delicate to accommodate the larvæ. They soon seek shelter, however, and bore into the main stem or other parts of the plants that offer protection. In some instances during studies of migration, the young larvæ have been found to be less susceptible to light than older larvæ, a condition that is undoubtedly comparable to the activity of the newly hatched larvæ in the habit of surface feeding before burying themselves within the tissues of the food plant.

During 1924 observations were made on the reaction of adults of this insect to light with regard to the deposition of eggs. For this purpose two simple cages were necessary; first, a lighted cage, that is a cage artificially lighted at all times, and second, a darkened cage or a chamber that was kept constantly dark. The first of these cages was intended to imitate a condition of constant daylight while the second was designed to produce an effect of perpetual night. Two such cages were constructed, each being about five feet long, three feet high, and three feet wide. They were built on a rough table in an insectary and were constructed of heavy black paper tacked on wooden frames, each provided with sliding doors and the necessary ventilation to insure as near natural conditions as possible. The insectary was open and screened on all sides but partly drawn shades excluded direct sunlight. The light provided in one cage was furnished by two 115 volt, 200 watt, electric light bulbs that hung from the top of the cage. This light while not actually comparable to the intensity of sunlight was nevertheless quite bright, perhaps more nearly approaching the light intensity prevailing in the sheltered places under natural conditions in which the resting adults spend the day. Three thermograph instruments were used in these studies, one being kept in each cage, and one with the control experiments so that a careful check on possible variation in temperature under which the various series of experiments were conducted was obtained. It was found that the temperature in the light cage usually ranged a few degrees higher than in the checks, while in the dark cage the temperature was sometimes lower than the check but more often was quite comparable. The temper-

*In a chart comparing the energy intensity and wave lengths of light where sunlight is considered as 100, the spectrophotometric curve for the electric bulbs used in these experiments runs from a relative energy of 30 at a wave length of .44μ to a relative energy of 210 at a wave length of .67μ in a nearly straight line. The possible effect of polarized light has not been considered in these experiments.

ature factor is not considered in the results obtained in these experiments because the variation was thought to be insufficient to materially affect the results. The writer has already studied the effect of temperature on the oviposition and length of life of these insects (Ecology VI, p. 39, 1925).

In each individual experiment a pair of moths, one of each sex, were confined in a lantern globe, the top of which was covered with cheese cloth. The lantern globe was set in a flower pot containing sand which was kept moist. A few leaves of a favored host plant were provided for oviposition and these were kept fresh by placing the stems in a vial of water set upright in the sand. The adults used in each series, including the checks were of individuals that had emerged from pupæ during the preceding 24 hours, and all cages of each series were started at the same time and were kept under identical conditions. The factor of humidity was fairly well controlled by keeping the sand contained in the flower pots moist at all times, so that all cages of a series were comparable in this respect. For the purpose of these experiments mention of "day" means the hours from dawn to dusk while "night" indicates the hours from dusk to dawn.

The work done on the relation of oviposition to light falls naturally under the following headings:

1. Oviposition of moths subjected to constant light.
   Oviposition of moths subjected to constant darkness.
2. Reaction of moths to an increase in the number of hours of light; i. e., prolonging the day.
   Reaction of moths to an increase in the number of hours of darkness; i. e., prolonging night.
3. Reaction of moths subjected to alternating dark and natural days.
   Reaction of moths subjected to alternating light and natural nights.
4. Reaction of adults subjected to alternating periods of life under normal conditions and in constant light.

Oviposition of moths subjected to constant light and constant darkness.

Six series of experiments relating to this subject were completed, each consisting of 15 individual cages, of which five were kept in the light cage, five in the dark cage and five remaining under natural insectary conditions throughout the period of life of the individuals. These series of experiments were started on June 6, June 7, June 9, June 16, June 29 and July 4,

1924. The general results of these experiments may be shown best in Table I.

It is apparent from a study of these results that constant light considerably reduced the length of life of both sexes of adults in the cages subjected to this condition and resulted in a considerably smaller deposition of eggs and in a smaller number of masses than in the case of the control. Constant darkness, while not apparently affecting the length of life of the moths, did cause the females to deposit a larger number of eggs in a larger number of masses, deposited on a greater number of

TABLE I.

EFFECT OF CONSTANT LIGHT AND CONSTANT DARKNESS ON RATE OF OVIPOSITION OF THE EUROPEAN CORN BORER.

	Average Length of Life of Adults		Average Number of masses of Eggs Deposited	Average Number of Eggs Deposited	Average Number of Days on which Eggs were Deposited	Average Number of Eggs Deposited Per Female Per Day	
	Male	Female				Of Length of Life	Per Day on which Eggs were Layed
Adults subjected to constant light	14.7	14.4	16.1	267.2	5.3	18.5	51.3
Adults subjected to constant dark	21.8	17.1	26.3	347.4	9.8	20.3	35.4
Checks: adults kept under natural conditions of the insectary	20	18.5	21	324.3	8.6	17.5	37.7

days than in the check. On the other hand, although adults lived for a shorter average period when subjected to constant light, the average number of eggs per female deposited daily in comparison with the average length of life of such individuals, was somewhat larger than in the case of the check. It also was observed that the average number of eggs per female compared with the number of days on which eggs were laid was considerably greater in the case of individuals subjected to constant light than in the case of those under natural insectary conditions. In like manner, while adults subjected to constant darkness deposited a somewhat larger average number of eggs per day of life than in the case of the checks, when the average deposition per female is compared with the average number of days on which eggs were deposited, the number of eggs deposited by the individuals of the experiment is found to be somewhat

less than in the case of the individuals kept under natural insectary conditions. In Table II adults are arranged in groups according to the number of eggs deposited.

Here it may be seen that adults subjected to constant light showed a larger proportion of abnormal females, or individuals that deposited an abnormally small number of eggs. If it may be said that normal females as shown by the check, deposited between 100 and 600 eggs each, it is shown in the table above that there were 14 such individuals that had been subjected to constant light, 19 such individuals that had been subjected

TABLE II.

FREQUENCY OF TOTAL EGG DEPOSITION OF MOTHS SUBJECTED TO CONSTANT LIGHT AND TO CONSTANT DARKNESS AND THOSE UNDER NATURAL INSECTARY CONDITIONS.

Range of the Total Number of Eggs Deposited	CLASSIFICATION OF MOTHS ACCORDING TO THEIR TOTAL DEPOSITION OF EGGS		
	Moths Subjected to Constant Light	Moths Subjected to Constant Darkness	Check: Moths Kept Under Natural Insectary Conditions
	Number of Individuals in Group	Number of Individuals in Group	Number of Individuals in Group
0	3	0	0
1—50	8	3	2
51—100	1	2	1
	12	5	3
101—200	1	5	6
201—300	2	5	3
301—400	6	4	6
401—500	5	3	8
501—600	0	2	3
	14	19	26
601—700	1	3	1
701—800	2	2	0
801—900	1	1	0
	4	6	1

to constant darkness and 26 such individuals that had been kept under the natural conditions of the insectary. It may also be seen that of adults subjected to constant light, an abnormal number produced few eggs or no eggs at all, while of adults subjected to constant darkness a somewhat increased number produced a very large number of eggs.

These cages were examined at 7:30 A. M. and 4:00 P. M. daily. It was found that 11 of the 30 females subjected to constant light deposited 711 of a total number of 8,017, or 8.8 per cent of their eggs between 7:30 A. M. and 4:00 P. M.; of the 30 females subjected to constant darkness, 28 deposited 1,999 out of a total of 10,421 eggs, or 19 per cent, between these hours; and 6 of the 30 females kept under natural insectary

conditions deposited 148 of a total of 9,729 eggs, or 1.5 per cent, between these hours. These observations, while not accounting for the deposition of eggs during the light hours of early morning or of evening, showed a definite tendency of the moths kept in perpetual darkness to deposit eggs during the hours of normal day. A less marked tendency in the same direction was indicated in the case of the individuals kept in constant light.

Reaction of moths to an increase in the hours of light, i. e., prolonging the day.

In these experiments, consisting of two series as previously explained, and which were begun on August 19 and August 20, 1924, the cages were placed in the light chamber at 1:00 A. M.

TABLE III.

REACTION OF MOTHS TO AN INCREASE IN THE NUMBER OF HOURS OF LIGHT.

	Average Length of Life of Adults		Average Number of Masses of Eggs Deposited	Average Number of Eggs Deposited	Average Number of Days on which Eggs were Deposited	Average Number of Eggs Deposited Per Female Per Day	
	Male	Female				Of Life	Of Days on which Eggs were Layed
Adults subjected to an increase in the number of hours of light	14.4	14.5	15.6	258.2	5.1	17.1	50.6
Checks: adults kept under natural conditions of the insectary	18.4	14.8	25.5	386	8.1	26	47.6

each day and removed to natural insectary conditions at 7:30 A. M., where they remained until 1:00 A. M. the following morning. This amounted to an increase of from three to three and one-half hours of light each day. As is shown in Table III, the adults so treated deposited a considerably smaller number of eggs than the individuals kept under natural insectary conditions as checks.

As in the cages kept in constant light, previously discussed, an increase in the number of individuals that deposited an abnormally small number of eggs resulted through the treatment of prolonging the hours of light. Thus, of the adults subjected to an increase in the hours of light, 4 deposited less than 100 eggs each, 4 deposited between 101 and 600 eggs each, and 2 deposited more than 600 eggs each. Of the adults kept under natural

insectary conditions as checks, none deposited less than 100 eggs, 8 deposited between 101 and 600 eggs each, and one deposited more than 600 eggs. One pair of moths of a check cage remained constantly in copulation till death, the male living for 8 days, the female for 12 days.

Reaction of moths to an increase in the number of hours of darkness, i. e., prolonging the night.

The experiments covered by this subject consisted of two series as previously explained, and were started on August 17 and August 18, 1924. The individual cages of these experiments were placed in the dark chamber at 4:00 P. M. and were removed at 7:30 A. M. the following morning, during the

TABLE IV.

REACTION OF MOTHS TO AN INCREASE IN THE NUMBER OF HOURS OF DARKNESS.

	Average Length of Life of Adults		Average Number of Masses of Eggs Deposited	Average Number of Eggs Deposited	Average Number of Days on which Eggs were Deposited	Average Number of Eggs Deposited Per Female Per Day	
	Male	Female				Of Life	Of Days on which Eggs were Layed
Adults subjected to an increase in the number of hours of darkness	19 2	16 2	22 7	290	7 3	18	39 9
Checks: adults kept under natural conditions of the insectary	21	17	26 2	459	8 8	27	52 1

period of life of the moths. This corresponded to an increase of from 6 to 6½ hours of darkness daily. Adults so treated deposited a smaller number of eggs than the adults of the checks, as is shown in Table IV.

Although females subjected to this treatment deposited a considerably smaller average number of eggs than the individuals of the check, there were fewer individuals that may be termed abnormal than in the case of individuals subjected to an increase in the number of hours of light daily, previously considered. Of adults subjected to an increase in the number of hours of darkness, one deposited less than 100 eggs, eight deposited between 101 and 600 eggs each, and one deposited more than 600 eggs. Of adults kept under natural insectary conditions as checks, nine deposited between 101 and 600 eggs each and one deposited more than 600 eggs.

Reaction of moths subjected to alternating dark and natural days.

Two series of experiments on this subject, as previously explained and which were begun July 11 and July 26, 1924, were completed. These adults were subjected to alternating dark days, that is, on the first day the insects were kept under natural insectary conditions, during the second day they were subjected to constant darkness throughout the hours of natural sunlight, on the third day they were under natural conditions, on the fourth subjected to constant darkness and so on through the duration of life. The following table shows the results from subjecting individuals to these conditions.

TABLE V.

REACTION OF MOTHS SUBJECTED TO ALTERNATING DARK DAYS.

	Average Length of Life of Adults		Average Number of Masses of Eggs Deposited	Average Number of Eggs Deposited	Average Number of Days on which eggs were Deposited	Number of Eggs Layed on Dark Days	Number of Eggs Layed on Natural Days
	Male	Female					
Adults subjected to alternating dark days.....	12.8	19.3	25.6	394.5	8	725	0
Checks: Adults under natural insectary conditions.....	17.5	19.1	19.4	262.1	7.2	14	7

Alternating dark days appeared to considerably increase the average deposition of eggs of individuals subjected to these conditions, while not materially affecting the average length of life of the females. The number of eggs deposited on dark days as compared with the number of eggs deposited on normal days by the females of the experiment was especially noticeable. These moths deposited 18.4 per cent of their total egg production on the days when subjected to constant darkness while on days spent under natural conditions no eggs were deposited. On the days when the moths of the experiment were subjected to darkness, the checks which had remained under natural conditions deposited about 0.5 per cent of their total egg production.

Reaction of moths subjected to alternating and natural nights.

In these experiments, consisting of two series as previously explained and which were started on July 7 and July 25, 1924, the adults were subjected to alternating light nights, that is, on the first night of life they remained under natural insectary conditions, on the second night of life they were kept in the light chamber, on the third night under natural conditions, on the fourth night subjected to constant light and so on during the continuance of life of the individuals. The following table shows the details of oviposition of adults subjected to these conditions.

TABLE VI.

REACTION OF MOTHS SUBJECTED TO ALTERNATING LIGHT NIGHTS.

	Average Length of Life of Adults		Average Number of Masses of Eggs Deposited	Average Number of Eggs Deposited	Average Number of Days on which Eggs were Deposited	Number of Eggs Layed on Light Nights	Number of Eggs Layed During Days of Life	
	Male	Female					All Days	Days Following Light Nights
Adults subjected to alternating light nights.....	12.8	14.9	12.7	200.9	5.9	790	251	132
Checks: adults under natural insectary conditions.....	16.3	16.1	18.6	296.2	6 6	1752	17	0

The adults subjected to alternating light and natural nights in these experiments lived for shorter average periods than the normal individuals of the check and deposited an appreciably smaller number of eggs. During the nights on which they were subjected to light the moths of the experiment deposited a much smaller number of eggs (39 per cent of the total deposition) than did the checks (59.1 per cent of the total deposition), and the abnormal conditions that they were subjected to resulted in some oviposition during the day, while the checks deposited an insignificant number of eggs during the hours of daylight.

Reaction of adults subjected to alternating periods of life under natural conditions and in constant light.

The experiments that fall under this heading consisted of two series as previously explained and were begun on August 15 and August 16, 1924. The individuals of the experiment were subjected to alternating periods of life under natural insectary conditions and periods in constant light as follows: during the first five days of adult life, the individuals were under natural conditions, they were then subjected to a period of five days in constant light by being placed in the light chamber previously described. During the third five-day period they were again under natural insectary conditions and were then again subjected to a period of five days in the light chamber. The results of this work are shown in the following table:

TABLE VII.

REACTION OF ADULTS SUBJECTED TO ALTERNATING PERIODS OF LIFE UNDER NATURAL CONDITIONS AND IN CONSTANT LIGHT.

	Average Length of Life of Adults		Average Number of Masses of Eggs Deposited	Average Number of Eggs Deposited	Average Number of Days on which Eggs were Deposited	Number of Eggs Layed During Light Periods	Percent of the Total Number of Eggs that were Deposited During Light Periods
	Male	Female					
Adults subjected to alternating periods..	13.1	16.2	19.9	329.1	7.2	816	24.8
Checks: Adults under natural insectary conditions.....	17.6	15.3	24.7	358.4	8.6	1746	48.7

While these experiments failed to show an appreciable reduction in the total oviposition of adults subjected to alternating periods of life under natural conditions and periods in constant light as compared with the checks, it is shown that during the periods when the individuals were subjected to constant light the egg production was only 24.8 per cent of the total number of eggs deposited, as compared with a deposition of 48.7 per cent of the total number of eggs that was deposited by the individuals of the check during the same periods. When the numbers of eggs deposited by the moths of the experiment and of the check are compared period by period the reduction of egg production is shown to be more clearly associated with the different conditions of life as is shown in Table VIII.

Here it is shown that during the first five-day period in the life of these adults, when the moths of the experiment were under natural insectary conditions, they deposited 8 per cent more of their total egg production than did the checks. During the second five-day period when they were subjected to constant light, they deposited 23 per cent less of their total egg production than did the checks. In the third five-day period when the moths of the experiment were again under natural conditions they deposited 15.9 per cent more of their total egg

TABLE VIII.

NUMBER OF EGGS DEPOSITED BY ADULTS DURING ALTERNATING PERIODS UNDER NATURAL INSECTARY CONDITIONS AND WHEN SUBJECTED TO CONSTANT LIGHT.

	Egg Production During First Five Days of Life		Egg Production During the Sixth to Tenth Days of Life		Egg Production During Eleventh to Fifteenth Days of Life		Egg Production During the Sixteenth to the Twentieth Days of Life	
	Natural Insectary Conditions		Subjected to Constant Light		Natural Insectary Conditions		Subjected to Constant Light	
	Number of Eggs	Per Cent of the Total	Number of Eggs	Per Cent of the Total	Number of Eggs	Per Cent of the Total	Number of Eggs	Per Cent of the Total
Adults subjected to alternating periods of life under natural conditions and constant light...	1608	48.8	786	23.9	867	26.3	30	.9
Check: Adults under natural insectary conditions.....	1464	40.8	1682	46.9	374	10.4	64	1.8

production than did the checks. Finally, during the fourth five-day period when they were for a second time subjected to a period of constant light the surviving individuals deposited .9 per cent less of their total egg production than did the survivors of the check. Therefore, during each light period the moths of the experiment deposited approximately half the proportion of their full egg production that the individuals of the check produced during the same periods. After the forced partial rest occasioned by the first period of constant light, a return to natural conditions resulted in a notable stimulation in oviposition, and it seemed as if the insects endeavored to make up for lost time in this respect.

SUMMARY.

In the observations recorded in this paper, adults of the European corn borer (*Pyrausta nubilalis* Hubn.) were subjected to various periods of life in constant light and constant darkness to observe what effect these conditions would have on the length of life of individuals and on the number of eggs that they would deposit. Experiments concerning the following points were conducted; individuals subjected to constant artificial light, to constant darkness, to a daily increase in the number of light hours, to a daily increase in the number of dark hours, to alternating dark and natural days, to alternating light and natural nights and to alternating periods of life under natural conditions and constant light.

The general results of these experiments showed that when subjected to constant light the adults lived for shorter periods, a greater proportion of females were abnormal in that they produced few eggs and the average egg production was considerably reduced, although the egg production per day of life was somewhat larger than in the case of the checks, which deposited a larger number of eggs over a longer period of time. Individuals subjected to constant darkness were not appreciably affected as to length of life, but produced a somewhat larger number of eggs than the checks. Adults subjected to constant light deposited an average of 8.8 per cent of their total egg production between 7:30 A. M. and 4:00 P. M., adults subjected to constant darkness deposited 19 per cent of their total egg production between these hours while in the checks 1.5 per cent of the total egg production was produced between these hours.

Adults subjected to an increase of from three to three and one-half hours of light each day deposited a considerably smaller number of eggs than the checks, and this condition resulted in an increased proportion of individuals that deposited abnormally small number of eggs. Individuals subjected to an increase of from six to six and one-half hours of darkness each day deposited a considerably smaller number of eggs than the checks, but fewer individuals that deposited abnormally small number of eggs resulted than in the case of adults subjected to an increase in the number of hours of light each day.

Adults subjected to alternating dark days and natural days produced a considerably larger number of eggs than the checks, 18.4 per cent of the total number being deposited during the

dark days as compared with no deposition on natural days and a very small number of eggs deposited during the light hours by the checks. Individuals subjected to alternating light nights and normal nights deposited a considerably smaller number of eggs than the checks, 39 per cent of their total egg production being deposited during the light nights, while during the same nights the individuals of the check deposited 59.1 per cent of their total egg production.

Alternating periods of life under natural conditions (5 days) with equal periods under constant light, while not causing a noteworthy difference in the length of life or in the number of eggs produced, did affect the rate of oviposition. Thus, while the checks produced 48.7 per cent of their total number of eggs during the time when the adults of the experiment were subjected to constant light, the latter deposited only 24.8 per cent of their total egg production during such periods. This is shown especially well when the oviposition during each period is compared with the total egg production. During the first five day period, when the moths of the experiment were under natural insectary conditions, they produced 48.8 per cent of their total egg deposition, the checks depositing 40.8 percent of their total egg production during this time. From the sixth to the tenth day, when the individuals of the experiment were subjected to constant light, they deposited 23.9 per cent of their total egg production, while at the same time 46.9 per cent of the total egg production was produced by the checks, in the third period, the eleventh to the fifteenth days, when the individuals of the experiment were again under natural insectary conditions, they produced 26.3 per cent of their total deposition, while at the same time 10.4 per cent of the total deposition was produced by the checks. Finally, from the sixteenth to the twentieth days, when the moths of the experiment were once more subjected to constant light, the survivors of the experiment produced 0.9 per cent of their total egg deposition, while during this period the survivors of the check produced 1.8 per cent of their total deposition.

From a consideration of these experiments it appears that constant light, increased hours of light each day, alternating light nights or periods of a few days of life under constant light caused a considerable reduction in the number of eggs, while constant darkness or alternating dark days stimulated the production of eggs by adults under such conditions.

A REVIEW OF THE GENUS ACLERDA (HEMIPTERA; COCCIDOIDEA).

By MILTON M. TEAGUE,
Stanford University, California.

At the suggestion of Professor G. F. Ferris, of the Department of Zoology of Stanford University, I have undertaken the following review of this small group of the scale insects. The material upon which the paper is based is contained for the most part in the Stanford Collection of Coccidæ. Specimens of *Aclerda holci* n. sp. were obtained through the kindness of Mr. H. K. Plank, of the United States Bureau of Entomology and the holotype of this species will be deposited in the National Collection of Coccidæ.

SYSTEMATIC POSITION OF THE GENUS ACLERDA.

At the request of the writer, Professor G. F. Ferris has prepared the following statement in regard to this genus.

"The genus *Aclerda* consists of a very homogeneous group of species that seem to have no very clear connection with any of the other coccidoid groups. By some of the earlier authors it was placed in the so-called sub-family Dactylopiinae, a group that was merely a heterogeneous collection of genera many of which should be reffered to other groups. Later authors have quite generally followed the placing that was established by the Fernald catalogue and have regarded the genus as a member of the sub-family Coccinæ (or Lecaniinæ), although Green in 'The Coccidæ of Ceylon' has questioned this position and has called attention to the apparently isolated position of the genus.

"I am entirely in accord with Green in these views. I am unable to see that the genus has anything to do with the Coccinæ (or Lecaniinæ), for the ducts are of an entirely different type and the anal plates are dis-similar. The first stage nymph confirms this separation. Neither do the ducts show any close relationship to any other group. Consequently I regard the genus as by itself constituting a group which, following my personal views, I would call the family Aclerdidæ of the super-family Coccidoidea.

"The family may be defined, in the adult female, by the following characters: Coccidoidea without abdominal spiracles; apex of the abdomen with a cleft at the base of which is the anal opening, this covered by a single plate which is sometimes deeply cleft but is never completely divided; anal opening apparently without a distinct ring, the alimentary canal terminating in many slender processes; tubular

ducts present, never with a filamentous inner prolongation; margin of the body beset with small tuberculiform setæ; adult female always with the legs entirely lacking and with the antennæ reduced to mere tubercles."

Previous Systematic Work.

The previous systematic work on the genus *Aclerda* consists almost entirely of descriptions of individual species and there is no treatment of the genus as a whole. Probably the best of the individual descriptions is that of *Aclerda distorta* in Part IV of Green's "Coccidæ of Ceylon." Buffa has given an extended account of *Aclerda berlesii* in Vol. VI, of the Revista di Patologia Vegetale.

With the exception of a short period when some of the species were referred to the genus *Pseudolecanium* and the reference of one or two to the genera *Nidularia* and "*Sphererococcus*," the members of this genus have always been referred to by its present name. Very few of the species are at all recognizable on the basis of the existing descriptions.

Scope of the Present Paper.

Owing to limitations of time and of material this paper will consider but the adult females. Nine species, of which two are described as new, are here dealt with. There remain six described species in the genus of which I have not been able to see material.

Geographical Distribution.

The existing records show that the members of this genus are widely distributed. Species have been recorded from all of the continents except South America. In view of the fact that the grass-infesting Coccidæ have usually been more or less neglected, it is probable that many more species remain to be discovered.

Economic Importance.

The members of the genus are of little or no economic importance. One species, *Aclerda sacchari*, which is here described as new, has been taken from sugar cane and may possibly achieve some economic standing. Others have been taken from bamboo and the remainder are confined to various wild grasses.

Habit.

As already indicated, the members of this genus are known only from grasses on which they are most commonly found beneath the sheathing bases of the leaves. In some cases, *A. californica* for example, they may occur among the roots. They are generally imbedded in more or less white secretion of amorphous form. They are probably ovo-viviparous.

Morphology of the Adult Female.

Form.—The form differs greatly among the various species and it is possible that it would be characteristic for each species were it not that individuals are almost always more or less distorted by their crowded positions. They are often bent and twisted to conform to their surroundings and in some forms a certain peculiar distortion appears to be normal, as in *A. distorta*.

Chitinization.—The body at maturity becomes wholly or in part very heavily chitinized except in the median and extreme anterior portion. The posterior end of the body, especially, is always heavily chitinized and is usually more or less strongly marked by furrows that cause a wrinkled appearance.

Mouthparts.—In the species examined the mouthparts show no distinctive characters. Green, Coccidæ of Ceylon, Pt. IV, p. 290. says, "Mouthparts approximately central, often displaced towards one side, mentum monomerous." However, there is nothing distinctive in this.

Antennæ.—In speaking of the antennæ in this genus MacGillivray (The Coccidæ) says, "Antennæ represented by unsegmented tubercle on each side." This is but partially true. In most species the antennæ are as thus described, but in *A. ariditatis* there are vestigial segments which can be seen quite clearly. These segments are not more than two and seem to be essentially alike. The antennæ are located a little cephalad of the mouthparts.

Spiracles.—The thoracic spiracles are large and conspicuous. In some specimens the posterior pair seem to be somewhat broader than the anterior, but this difference, if it exists, is very slight. Some specific differences appear. Laterad of each spiracle there is in all cases a group of pores borne upon a stigmatic plate. In some species this group of pores is very narrow and there are relatively few, while in others the area is much wider and the number greater (Pl. XXXI, I. J. K). These pores have the form merely of irregular openings in the plate.

Legs.—Legs are entirely lacking in the adult female.

Setæ, pores and ducts.—The lateral margins of the body, with the exception in some species of the posterior chitinized portion, are beset with small, tubercle-like setæ. These may appear in a single row or in an irregular zone and are of different types in the different species. In some cases they are somewhat spear-head-shaped, in others they are rounded at the tips and in others they are somewhat acorn-shaped

(Pl. XXXI, f. B-G). These peculiar setæ are accompanied by tubular ducts of a form that is peculiar to this genus. These ducts (Pl. XXXI, f. N) are cylindrical and have the inner extremity heavily chitinized and slightly cup-shaped. There is definitely no filamentous prolongation of this duct such as appears in *Pseudococcus, Eriococcus, Lecanium* and similar forms.

There are frequently present also numerous extremely small, tubular ducts, which as nearly as may be determined, have the structure shown in Pl. XXXI, f. Q). In certain species there are present also numbers of a peculiar type of duct (Pl. XXXI, f. R) which seems to consist essentially of a more or less heavily chitinized tube, the outer opening of which is closed by a dome-shaped cap that is apparently pierced by many small pores, these giving the duct when viewed from its end a "pepper-box" appearance. Circular pores of the type shown in Pl. XXXI, f. O. P are present in one species, *A. californica*, only.

Anal structures.—Considerable difficulty is experienced in determining the exact nature of the structures in the anal region because of the extremely heavy chitinization. The anal cleft is usually short, continuing on the ventral side as a furrow and covered at its base on the dorsal side by a plate or operculum which is free except at its base. This plate varies much in form among the different species and is apparently in most cases a very useful specific character. In *A. subterranea* it is cleft almost to is base (Pl. XXXII, f. B). In fact it is in this species almost divided into two plates as in *Lecanium*, although we feel sure that the division is not complete. The setæ on the plate are quite prominent and vary in number from four to ten. In one species, *A. californica* (Pl. XXXIII, f. I) there is a considerable variation of form, but in most of the species this appears to be relatively constant.

A retractile anal tube is present, which seems to terminate in many flattened hairs that form a fringe. They are apparently not setæ. The position of the anus seems to vary with the different species. In some it is situated immediately beneath the anal plate while in others it is cephalad of the plate.

The very obscure vaginal opening is at the anterior extremity of the ventral furrow that is continuous with the anal cleft. There seem to be no special pores associated with it.

Partial Key to the Species of Aclerda.

Only those species are included of which it has been possible to see specimens.

1. Tuberculate marginal setae accompanied by a zone of stellate circular pores. *californica*
   Marginal setae not accompanied by a zone of such pores.....2
2. Anal plate cleft almost to the base.....*subterranea*
   Anal plate with at the most a slight apical cleft.....3
3. Anal plate with the apex more or less cleft.....4
   Anal plate with the apex rounded or truncate, never cleft.....6

4. Zone of marginal tuberculate setae extending almost to the margin of the anal cleft; anal plate short and broad, not pointed.....*tokionis*
   Zone of marginal tuberculate setae ceasing at some distance from the margin of the anal cleft.....5
5. Setæ on the anal plate very small; spiracles with narrow pore plate..*holci* n. sp.
   Setæ on the anal plate quite large and long; spiracles with large, broad pore plate.....*berlesii*
6. Marginal tuberculate setæ extending nearly or quite to the margin of the anal cleft.....*distorta*
   Marginal tuberculate setæ ceasing more or less remotely from the anal cleft..7
7. Tuberculate setæ dome-shaped, not fusiform.....*attenuata*
   Tuberculate estæ distinctly fusiform; not dome-shaped.....8
8. Dorsum of the apical portion of the abdomen much wrinkled; tuberculate setæ rounded at the apex.....*ariditatis*
   Dorsum of the apical portion of the abdomen almost smooth; tuberculate setæ sharply pointed.....*sacchari* n. sp.

Aclerda ariditatis Ferris.

Pl. XXXI, f. G, I, M; Pl. XXXII, f. B; Pl. XXXIII, A. L.

1919. *Aclerda ariditatis* Ferris, Contribution to the Knowledge of the Coccidæ of Southwestern United States, Stanford University Publ., University Series, p. 34; f. 15.

Type host and locality. From a perennial grass, probably *Hilaria cenchroides*, on the Jornado del Muerto north of Las Cruces, New Mexico.

Material examined. The type material.

Morphological characteristics. Length (on slide) about 2 mm. Form usually elongate, varying with the habit and sometimes nearly circular. Posterior portion of the abdomen heavily chitinized and presenting a much wrinkled appearance (Pl. XXXII, f. B). Remainder of the derm smooth and membranous. Marginal tuberculate setæ in a single or irregularly double row, ending remote from the anal cleft. These setæ are broadly rounded at the tip (Pl. XXXI, G). Mingled with these setæ and also further back from the margin (Pl. XXXIII, f. L) and in the apical chitinized portion are numbers of large tubular ducts. Anal plate (Pl. XXXII, f. A) undivided and possessing as many as ten long, prominent setæ.

Aclerda attenuata Ferris.

Pl. XXXII, f. D; Pl. XXXIII, f. G, P.

1921. *Aclerda attenuata* Ferris, Report upon a Collection of Coccidæ from Lower California, Stanford University Publications, Biological Sciences 1 : 2 : 87; f. 11.

Type host and locality. Type from *Distichlis spicata*, La Rivera south of La Paz, Lower Claifornia, Mexico. Also from bamboo at the same place and at Todos Santos in the same region.

Material examined. Type material.

Morphological characteristics. Length varying greatly, ranging in the material examined from 3 to 9 mm. Form varying in width according to the host but always remaining elongate. Some specimens have the posterior portion of the body twisted to one side, but this is not constant. Derm very heavily chitinized in the caudal region and with

many shallow furrows both dorsally and ventrally in this area (Pl. XXXII, f. D). Tuberculate setæ arranged in a narrow zone (Pl. XXXIII, f. P) which ends remote from the anal cleft, the space between the ends of this zone and the anal cleft being occupied by slender setæ. Tuberculate setæ of two types, some almost dome shaped, others elongate, but always bluntly rounded at the tip and not constricted at the base. The characteristic tubular ducts are present among the marginal setæ and in the chitinized caudal area. Anal plate (Pl. XXXIII, f. G) elongate, tapering toward the tip, bearing several large setæ, the number of which is apparently not constant.

Aclerda berlesii Buffa.

Pl. XXXII, f. C; Pl. XXXIII, f. H.

1897. *Aclerda berlesii* Buffa, Revista Patologia Vegetale 6 : 135.
1898. *Aclerda berlesii* Buffa, Berlese and Leonardi, Chermotheca Italica, fasc. 3; No. 63.

Type host and locality. Italy, on *Arundo donax*.

Material examined. Specimens from the Chermotheca Italica, from *Arundo donax*, Italy. These are from the Woglum collection of Coccidæ which is on loan deposit at Stanford University.

Morphological characteristics. Length 6–10 mm. Form oval. Posterior portion of the abdomen (Pl. XXXII, f. C) very heavily chitinized, this chitinization extending cephalad around the margins in some cases; quite deeply furrowed. Zone of marginal setæ ending remote from the anal cleft; setæ of two types, a dome-shaped form and a sharply pointed, acorn-shaped form being present. Typical tubular ducts are present among these setæ and also in the caudal chitinized region. In addition to these there are present in the caudal area numerous small ducts with the "pepper box" pore (Pl. XXXI, f. R). Anal plate (Pl. XXXIII, f. H) of a characteristic form, its base and margins rounded and tapering to a sharp point which is distinctly cleft, this cleft being much more apparent than is indicated in the original description.

Aclerda californica Ehrhorn.

Pl. XXXI, f. D, J, O, P; Pl. XXXII, f. A; Pl. XXXIII, f. I, K.

1897. *Nidularia californica* Ehrhorn, Canadian Entomologist 31 : 103.
1900. *Pseudolecanium californicum* (Ehrh.), Parrot, Kansas Experiment Station Bulletin 98 : 45.
1920. *Aclerda californica* (Ehrh.), Ferris, Scale Insects of the Santa Cruz Peninsula, Stanford University Publications, Biological Sciences 1 : 1 : 32; f. 13.

Type host and locality. Originally described from an unidentified grass near Stanford University, California. Later recorded by Parrot from *Andropogon furcatus* in Kansas.

Material examined. From undetermined grass near Stanford University, California, and at Adrian, Washington.

Morphological characteristics. Length from 2 to 6 mm. Specimens varying greatly in shape, but generally oval. Posterior portion of the body (Pl. XXXII, f. A) heavily chitinized and with numerous furrows both dorsally and ventrally. The characteristic tubular ducts of the

genus are scattered irregularly over the body. Marginal tuberculate setæ (Pl. XXXIII, f. K) lacking in the caudal region, elsewhere in an irregular single or double row; setæ varying in size but all of the same general shape (Pl. XXXI, f. D), being broad at the base and terminating in a sharp point which gives them a characteristic "acorn-shape." Lying within the area of tuberculate setæ is a zone of prominent multilocular pores with a characteristic stellate appearance (Pl. XXXI, f. O, P) these being peculiar to this species. Anal plate varying greatly in shape (Pl. XXXIII, f. I), some specimens tapering from a broad base to a sharp tip, others with a broad and even somewhat emarginate tip. In spite of this variation of the plate these specimens seem really all to belong to the same species.

Aclerda distorta Green.

Pl. XXXI, f. H; Pl. XXXII, f. I; Pl. XXXIII, f. D, N.

1909. *Aclerda distorta* Green, Coccidæ of Ceylon 4 : 290.

Type host and locality. From bamboo, Peradeniya, Ceylon.

Material examined. A single specimen from the type host and locality, received through the kindness of Mr. Green.

Morphological characteristics. Length as great as 12 mm. Form usually narrow and elongate. Posterior extremity characteristically distorted, being turned at right angles to the long axis of the body. Posterior portion of the abdomen (Pl. XXXII, f. I) very heavily chitinized, regularly and finely furrowed, this chitinization extending entirely around the margins of the body in a narrow zone. Marginal tuberculate setæ (Pl. XXXIII, f. N), in a narrow zone which extends entirely around the body to the very edge of the anal cleft; setæ of various sizes but usually rather small and slender with rounded tips. Anal plate (Pl. XXXIII, f. D) elongate, tapering gradually to a blunt tip and bearing several long setæ.

Aclerda holci n. sp.

Pl. XXXI, f. E; Pl. XXXII, f. F; Pl. XXXIII, f. C, O.

Type host and locality. From *Holcus halepensis*, New Orleans, Louisiana. Material received through the kindness of Mr. H. K. Plank.

Morphological characteristics. Length 2–4 mm. Somewhat elongate to nearly spherical; posterior portion of the body usually slightly distorted and at a slight angle to the longitudinal axis. Tuberculate setæ in an irregular row (Pl. XXXIII, f. O) which extends around the body except for a narrow region on each side of the anal cleft. Between the ends of this zone and the anal cleft (Pl. XXXII, f. F) there is a row of slender setæ. Tuberculate setæ of a characteristic form (Pl. XXXI, f. E), elongate, bluntly rounded at the apex and constricted toward the base. Ducts with pores of the "pepper box" type quite numerous on the anal chitinized area, which is somewhat wrinkled. Anal plate (XXXIII, f. C) rounded at the base and tapering to a point which is distinctly cleft; bearing several small setæ.

NOTE: In certain respects, notably the cleft anal plate, this species is most closely related to *A. berlesii*.

Aclerda sacchari n. sp.

Pl. XXXI, f. B, K; Pl. XXXII, f. H; Pl. XXXIII, f. F, M.

Type host and locality. From stalks of sugar cane, Arecibo, Porto Rico. Also from roots of sugar cane at Morovis, Porto Rico. Material received through the kindness of Mr. G. N. Wolcott.

Morphological characteristics. Length 3–5 mm. From circular to oval. Posterior portion of the body (Pl. XXXII, f. H), heavily chitinized and quite strongly furrowed. Remainder of the derm membranous. Tuberculate setæ in an irregular series (Pl. XXXIII, f. M), extending around the body except for a narrow area on each side of the anal cleft; these setæ somewhat elongate, and distinctly fusiform, pointed at the tip (Pl. XXXI, f. B). Spiracles (Pl. XXXI, f. K) with the stigmatic plate very small and narrow. Anal plate (Pl. XXXIII, f. F) oval, bluntly pointed, bearing several large setæ.

NOTE: This species seems to be most closely related to *A. ariditatis*, differing chiefly in the form of the tuberculate setae and the much less wrinkled caudal area.

Aclerda subterranea Signoret.

Pl. XXXI, f. C, R; Pl. XXXII, f. E; Pl. XXXIII, f. B.

1874. *Aclerda subterranea* Signoret, Ann. Soc. Ent. Fr. (5) 4 : 96.

Type host and locality. From *Agropyrum* and *Milium*, France.

Material examined. A single slide received through the kindness of M. Vayssiere of the Station Entomologique de Paris. From *Agropyrum*, Alpes Maritimes, France.

Morphological characteristics. Length 3–4 mm. Form oval. Posterior portion of the body (Pl. XXXII, f. E) heavily chitinized and more or less wrinkled, bearing numerous large ducts with the characteristic "pepper box" pores. Tuberculate setæ (Pl. XXXI, f. C) strongly fusiform, arranged in a narrow zone which ends at some distance each side of the anal cleft. Anal plate (Pl. XXXIII, f. B) of a very characteristic form, being cleft almost to the base, the two portions being connected merely by a very narrow yoke.

Aclerda tokionis (Ckll.)

Pl. XXXI, f. F; Pl. XXXII, f. G; Pl. XXXIII, f. E.

1896. *Sphærococcus* (*Pseudolecanium*) *tokionis* Ckll. Psyche 7: Suppl. 1 : 19.
1896. *Sphærococcus* (*Pseudolecanium*) *tokionis* Ckll., U. S. Dept. Agriculture, Technical Series, Bull. 4 : 49.
1899. *Pseudolecanium tokionis* (Ckll.), Ckll., Proc. Acad. Nat. Sci. Philadelphia, p. 263.
1901. *Pseudolecanium tokionis* (Ckll.), Kuwana, Proc. Calif. Acad. Sci. (3) 2 : 403.

Type host and locality. Tokyo, Japan, on bamboo. It has been recorded by Kuwana from bamboo at Stanford University, California.

Material examined. Part of that recorded by Kuwana from Stanford University.

Morphological characteristics. Length 4–5 mm. Form broadly oval. Posterior end of the abdomen. (Pl. XXXII, f. G) with the wrinkling which is so characteristic of most of the species in this genus entirely lacking except at the extreme margins of the body. Marginal tuberculate setæ (Pl. XXXI, f. F) small, bluntly pointed, strongly fusiform, forming a narrow zone which extends almost to the margins of the anal cleft. Anal plate (Pl. XXXIII, f. E) of a very characteristic form, almost circular with a broad notch in the posterior margin, this continuous with a narrow cleft.

SPECIES NOT EXAMINED.

Aclerda biwakoensis Kuwana.

1907. *Aclerda biwakoensis* Kuwana, Imperial Agric. Exper. Station of Japan, Bull. 1 : 117.

Type host and locality. From bamboo in Japan.
Note: Wholly unrecognizable from the description.

Aclerda digitata Cockerell.

1902. *Pseudolecanium digitatum* Ckll., Ann. Mag. Nat. Hist. (7) 9 : 24.

Type host and locality. From grass, Richmond, Natal, South Africa.
Note: Wholly unrecognizable from the description.

Aclerda japonica Newstead.

1901. *Aclerda japonica* Newstead, Ent. Mon. Mag. 37 : 84.

Type host and locality. From *Arundinaria japonica,* in botanical garden, England.
Note: The illustration of the setæ is the only thing in the original description that can throw any light on this species. The setæ are figured as being of the "acorn-shaped" type.

Aclerda obscura Parrot.

1900. *Pseudolecanium obscurum* Parrot, Kansas Exper. Station, Bull. 98 : 144.

Type host and locality. At the bases of stems of *Andropogon scoparius* at Lost Springs, Parson and Fredonia, and upon *A. scoparius* and *Sporobolus longifolius,* Green Mound, Kansas.
Note: The only distinguishing character given in the original description is the statement that in this species the marginal setæ are lacking. If this be the case the species is thus very easily separabile from any others of the genus.

Aclerda sella-hispanica Lindinger.

1913. *Aclerda sella-hispanica* Lindinger, Fauna Sudwest. Australia.

Note: The description of this species is not available to us.

Aclerda signoreti Lindinger.

1912. *Aclerda signoreti* Lindinger, Schildlause, p. 170.

Note: Absolutely unrecognizable from the original description.

EXPLANATION OF FIGURES.

PLATE XXXI.

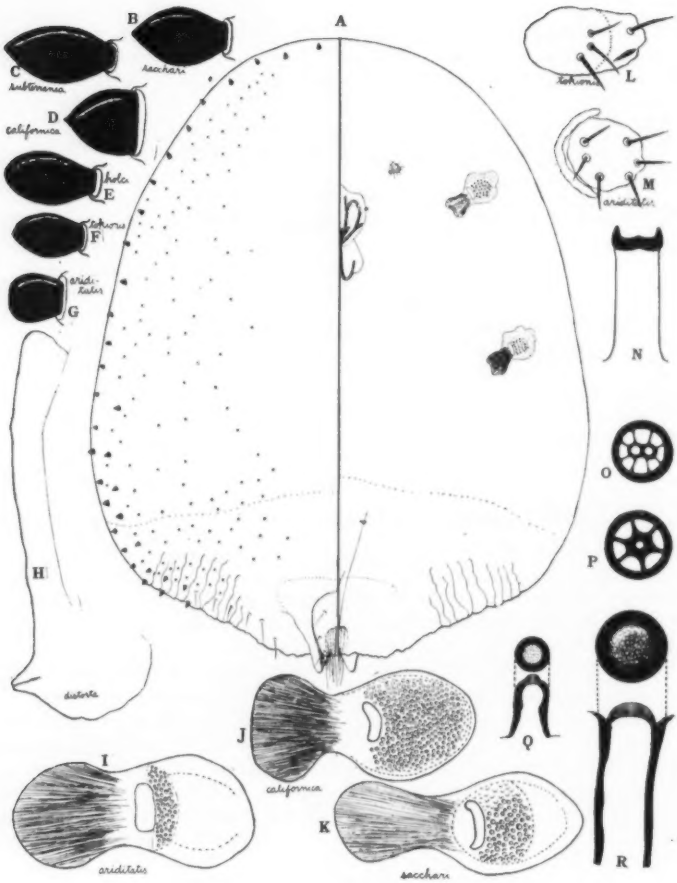
Fig. A. Generalized, diagrammatic drawing of *Aclerda*.
Figs. B–G. Types of tuberculate setæ.
Fig. H. Outline of portion of body of *A. distorta*.
Figs. I–K. Types of spiracles.
Figs. L–M. Types of antennæ.
Figs. N–R. Types of pores and ducts.

PLATE XXXII.

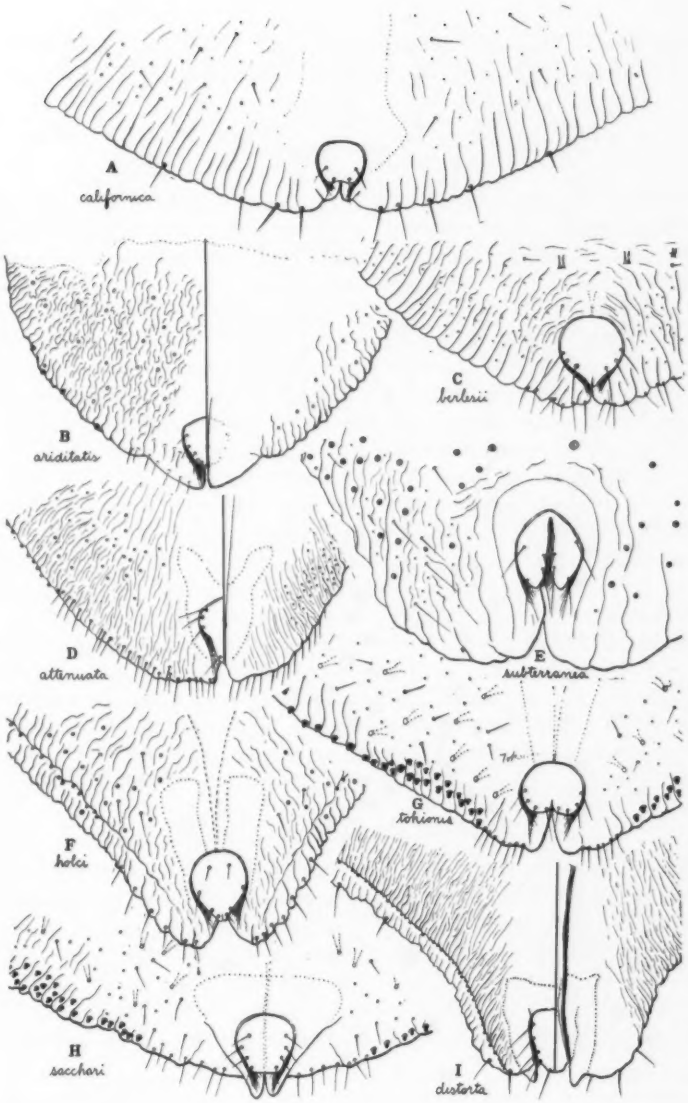
Figs. A–I. Posterior extremity of abdomen of species as indiacted by the labels.

PLATE XXXIII.

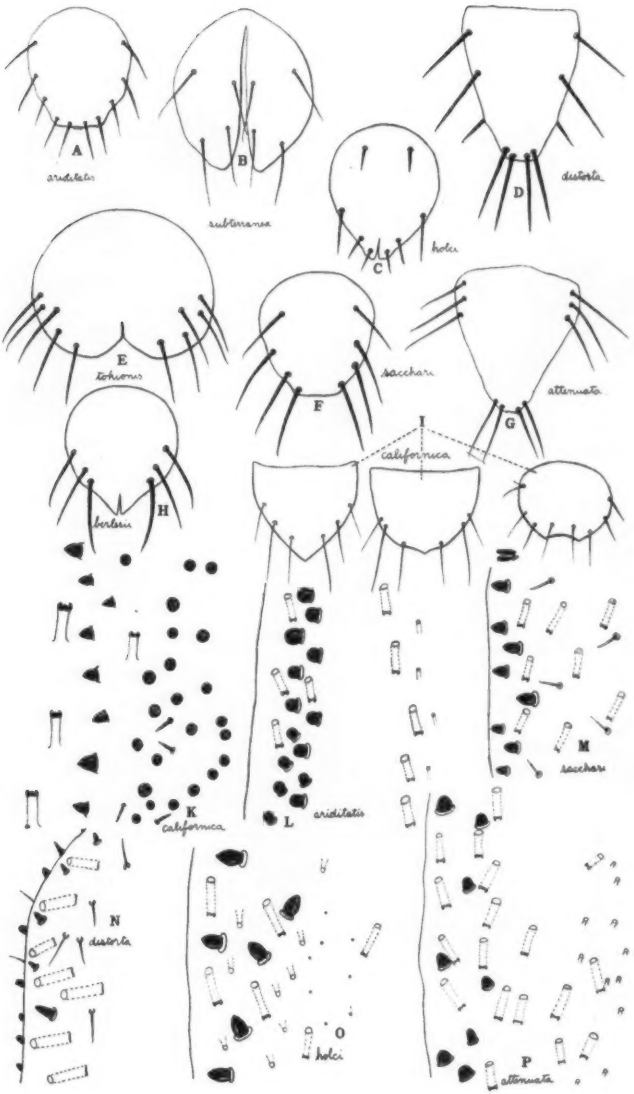
Figs. A–I. Anal plates of species as indictaed by labels.
Figs. K–P. Sections of marginal zones of setæ and pores of species as indicated by the labels.



Milton M. Teague



Milton M. Teague



Milton M. Teague

OBSERVATIONS ON THE ACROGLOSSAL BUTTONS AND ON THE SUBMENTUM OF HYMENOPTERA.

By CHUNG LO LIU,
Cornell University.

By reason of the attending difficulties in examination, the mouth-parts of insects have not been conceded their rightful place in insect taxonomy. That this department of anatomy offers important clues to the phylogeny of the hymenopterous insects has been indicated by Carl Börner in a classification of this order based largely on characters in the mouth-parts. The present study was initiated with a view to verifying Börner's findings relative to Vespoidea* by an examination of a large number of forms in that superfamily. But in the course of work attention became centered around two structures in the labium while the range of examination was extended to the entire order of Hymenoptera. The two labial structures studied are the submentum and, what is here termed, the acroglossal buttons. Observations on their anatomy and remarks on their taxonomic significance will be briefly presented below.

The writer takes pleasure in acknowledging his indebtedness to Dr. J. Chester Bradley, under whose direction the study was made. Acknowledgments are also extended to Mr. S. A. Rohwer for the loan of nine species from the United States National Museum, with permission to dissect them. The rest of the material used in this study was drawn from the entomological collections of Cornell University.

THE ACROGLOSSAL BUTTONS.

The acroglossal buttons are chitinous structures, subglobular to ovate in shape and located at the distal end of the lobes of the glossa of practically all the Vespid wasps. They have been noticed before and designated under a variety of names. Comstock and Kellogg (18:77) referred to each as a "button-like, chitinized tip"; MacGillivray (23:124) mentioned it as "a small brownish area"; Börner called it the

*The classification followed in this paper is that by Bradley, Rohwer and Bequært as partially published in Comstock's "An Introduction to Entomology," revised edition, 1924.

"löffelartige Bildung" (19:185), and the "löffelartige Anhang" (19:186); while Maidl (14:224) named it the "Hornpunkt". In view of the lack of an appropriate name, it is here proposed to call it the "acroglossal† button" by reason of its location and shape.

Typically the acroglossal buttons are located on the caudal surface of the glossa and bear at their distal margin a row of sensory setae. The position of both the buttons and the setae are modified in the more primitive forms of Vespidæ, but the setae are always found to be present on the buttons. Each seta is inserted in a pedestal, which when looked at from above gives the appearance of a circular pore with an elevated rim. Although these setae are constantly found on the acroglossal buttons, they are also present on the cephalic surface of the glossa of *Vespa*, *Polistes*, *Icaria*, *Belonogaster*, *Parapolybia*, etc., and along the mesal margin of the lobes of the glossa of *Zethus* and *Eumenes*. The other families of Vespoidea, as well as several families of the bees, are also found to bear these setae. From their position these setae have been supposed to be sense organs. Snodgrass (10:45), however, speaking of similar setae in the honey bee, thinks they function in affording protection to the delicate tip of the glossa. In dissecting the glossa of *Vespa maculata*, two muscular strands have been found to proceed from the base of the glossa, between the cephalic and caudal surfaces, and to terminate in knob-like enlargements which are appressed to the buttons. While final proof must await the demonstration of nervous tissues in these strands, the establishment of connections between the acroglossal buttons and the proximal portion of the glossa indicates that, in the hornet at least, the setae are more sensory than protective organs.

In connection with this work, fifty-two genera of the family Vespidæ and thirty-five species of the genus *Vespa* have been examined. With the single exception of *Euparagia scutellaris* Cress., all the members of Vespidæ have been found to bear the acroglossal buttons. While variations are not observed within the genus, profound modifications, both in respect to the position of the acroglossal buttons and of the sensory setae, have been noticed to occur within the family. For instance, in *Ceramius fonscolombei* Latr., and *Paraceramius lusitanicus* (Klug)., the buttons have forsaken their caudal position and become caudo-

† ακρος (=tip or terminal) γλωσσα (=glossa).

lateral, while in *Jugurthia oraniensis* Sauss., *Quartinia major* Kohl, *Celonites abbreviatus* Sauss., *Masaris vespiformis* Fabr., *Pseudomasaris vespoides* (Cress.) and *Trimeria buyssoni* Brethes, the acroglossal buttons have been completely transferred to the cephalic surface. The sensory setae in these eight forms are distributed irregularly over the surface of the buttons and are so very much reduced as to be visible only under an oil immersion lens. *Paraceramius* is further remarkable for the fact that although the setae on the acroglossal buttons are reduced, those on the buttons of the paraglossae are extraordinary long.

Vespidæ appears to be the only family of Hymenoptera possessing the acroglossal buttons in their true form. But in the glossae of the "long-tongued" bees (*Apis*, *Bombus*, *Psithyrus*, *Megachile*, *Osmia*, *Eucera*, *Xylocopa*, *Ceratina* and *Nomada*) similar terminal chitinizations are present in the form of chitin bands on the cephalic surface. The similarity between these structures and the acroglossal buttons is enhanced by the presence of sensory setae on the distal margin of the bands, and by the presence of forms in Vespidæ which have the terminal chitinization on the cephalic surface of the glossa. In fact, there is much ground for believing that these two structures are strictly analogous.

Again in the "long-tongued" bees mentioned above there is a structure at the distal end of the glossa, called the flabellum. In *Apis*, *Bombus*, etc., the flabellum is wholly protruded from the glossa, but in *Ceratina* and *Nomada* only the distal portion of this structure is protruded. The flabellum is spoon- or ladle-shaped, and, when not wholly protruded, occupies about the same position on the glossa as the acroglossal buttons in the Vespidæ. In fact, the term "bouton," according to Snodgrass, has actually been applied to the flabellum. Börner must also have been impressed by the remarkable resemblance between structures, as he calls the acroglossal buttons the "löffelartige Bildungen" after having named the flabellum the "Zungenlöffel" or the "Löffel." After a study, however, it is revealed that the flabellum never* bears any sensory setae

* Börner states that the sensory setæ (or his "Geschmackspapillen") are found on the distal margin of the flabella in his family Nomadidæ. (19 : 182). The writer has studied very carefully representatives of *Ceratina* and *Nomada*, and has found the flabella in these forms not even to bear the delicate processes as found in the flabellum of *Apis* or the fine hairs as in *Psithyrus*. The sensory setæ are located as in the other genera on the chitinous band on the cephalic surface of the glossa.

that serve as a distinguishing landmark for the acroglossal buttons; and it is further evident from its relation with a certain median, cartilagenous trough, the glossal rod of Snodgrass, that the flabellum has an origin very different from that of the acroglossal buttons. The acroglossal buttons and the flabella, therefore, are very different structures; hence the statement that Vespidæ appears to be the only family of Hymenoptera possessing the acroglossal buttons in their true form.

The acroglossal buttons, as mentioned above, have long been known to entomologists, but it was Carl Börner who first recognized their taxonomic value. He made use of these structures in characterizing his superfamily Vespina, or the family Vespidæ in the system of Bradley et al. While *Euparagia scutellaris* should be urged as an exception to his statement, the value of these structures as a family recognition character is not to be slighted. Furthermore, the acroglossal buttons are very prominent structures and can be easily seen if the mouthparts are pulled out as they should be in the proper preparation of hymenopterous insect specimens. The acroglossal buttons, therefore, constitute a character as useful in distinguishing the Diploptera as the longitudinal plaiting of their fore-wings.

It should be remarked here that, since no substitute or intermediate structures have been discovered among the "short-tongued" bees or the representatives of Sphecidæ, the analogy between the acroglossal buttons of the Vespidæ and the chitinous bands of the "long-tongued" bees, however perfect, is but an evidence of convergent development; and no phylogenetic significance may be attached to this analogy.

The Submentum.

The submentum of insects, when present, is the proximal of the two transverse sclerites at the basal part of the labium. It is very well developed in the more primitive orders of Hexapoda; and in a cockroach, it is the largest single sclerite of the labium, comprising no less than one half of that structure. In the higher insects the submentum may decrease in size or be entirely absent. Both of these conditions occur in the Hymenoptera, as will be seen from the following tabulation of the families:

			WITH SUBMENTUM	WITHOUT SUBMENTUM
CHALASTOGASTRA		1	Xyelidæ	
		2	Pamphiliidæ	
		3	Megalodontidæ	
		4	Siricidæ	
		5	Xiphydriidæ	
		6	Cephidæ	
		7	Blasticotomidæ	
		8	Cimbicidæ	
		9	Tenthredinidæ	
		10	Argidæ	
IDIOGASTRA		11		Oryssidæ
CLISTOGASTRA	ICHNEUMONOIDEA	12		Braconidæ
		13		Ichneumonidæ
		14		Megalyridæ
		15		Trigonalidæ
		16		Aulacidæ
		17		Stephanidæ
	SERPHOIDEA	18	Foenidæ	
		19		Monomachidæ
		20		Roproniidæ
		21		Heloridæ
		22		Vanhorniidæ
		23		Belytidæ
		24		Serphidæ
		25		Calliceratidæ
		26		Scelionidæ
		27		Platygasteridæ
		28		Pelecinidæ
	CYNIPOIDEA	29		Cynipidæ
	CHALCIDOIDEA	30		Chalcididæ
	EVANIOIDEA	31		Evaniidæ
	VESPOIDEA	32	Psammocharidæ	
		33		Embolemidæ
		34	Cleptidæ	
		35		Chrysididæ
		36	Plumariidæ	
		37	Anthoboscidæ	
		38	Sapygidæ	
		39	Thynnidæ	
		40	Tiphiidæ	
		41	Mutillidæ	
		42	Scoliidæ	
		43	Formicidæ	
		44	Bethylidæ	
		45	Rhopalosomidæ	
		46		Vespidæ
	SPHECOIDEA	47	Ampulicidæ	
		48	Dryinidæ	
		49	Sphecidæ	
		50	Hylaeidæ	
		51	Andrenidæ	
		52	Megachilidæ	
		53	Euglossidæ	
		54	Bombidæ	
		55	Apidæ	
		56	Meliponidæ	

Regarding the probable manner of atrophy of the submentum in the Hymenoptera, two theories have been advanced. The first view, which may be called the fusion theory, holds that the submentum is atrophied through fusion with the mentum. The second view, which will be called the "membranization" theory, maintains that the submentum appears absent due its becoming wholly membranous (MacGillivray 24:120). In his study the writer has examined a fairly large number of forms, and has taken advantage of this opportunity to weigh the plausibility of the two theories. It has been found that in many families, such as Tenthredinidæ, Megalodontidæ and most of the Vespoid families, the submentum is more or less widely separated from the mentum by a membranous area, and that in a few forms, such as *Megalodontes orientalis* Kirby, the submentum thus separated also has its boundary very indefinitely set off from the surrounding membrane. On the other hand, in *Evania princeps* Westwood and *Odontaulacus editus* Cresson, the boundary of the submentum is rather well defined by impressions, although the structure itself has lost all its chitin. All these observations seem to lend support to the membranization theory, although it is much less generally accepted than the fusion theory.

The thirty-three species of *Vespa* examined all exhibited uniformity in the complete atrophy of the submentum, and a study of fifty-one additional genera of Vespidæ strengthened the belief that uniformity in this respect probably extends throughout the whole family. It was then thought that this character might afford as good a family recognition character as the acroglossal buttons for the Vespidæ, and to see if this character was restricted to the Vespidæ, an examination was made of the submentum in all the fifty-six families of the order Hymenoptera. The results of this study have been presented above. While the number of representatives of some of the families studied is too small to warrant safe generalizations, a few interesting observations may be made with propriety:

1. The presence or atrophy of the submentum does not indicate dichotomy among the families. The atrophy, as a matter of fact, is not uniform within the superfamily. In Chalastogastra, the submentum is present in all the families, while in Idiogastra, it is absent. In Clistogastra, the con-

dition is more variable: Sphecoidea is probably the only superfamily that does not contain any form lacking the submentum, while Serphoidea, Cynipoidea, Chalcidoidea and Evanioidea all appear to be characterized by the absence of that structure. By possessing the submentum, Foenidæ proves to be as much an exception to Ichneumonoidea as the three submentum-lacking families, Embolemidæ, Chrysididæ and Vespidæ, to Vespoidea.

2. It is very probable that the atrophy of the submentum is uniform within the family. The separation, on other grounds, of *Foenus* (*Gasteruption*) from Evaniidæ, together with the result of the study of the Vespidæ, points to such a conclusion.

3. The forms lacking the submentum are pre-eminently the parasitic forms of the order, Vespidæ being the only important exception.

4. While complete atrophy of the submentum appeared first among the Oryssids, the tendency toward atrophy as shown by the separation of the submentum from the mentum, was exhibited very early in the phylogeny of the order, (Pamphiliidæ and Tenthredinidæ). The atrophy undoubtedly has arisen several times in connection with the families partaking of this character, as indicated by the heterogeneity of the families lacking the submentum.

5. The atrophy of the submentum is not the result of the different modes of feeding. Foenidæ which in all probabilities feed in the same manner as the Stephanids, possess the submentum, while Vespidæ, which share the typical lapping and sucking mouth-parts with the Sphecids, lack the submentum altogether.

List of Species Studied.

Due to the rarity of some of the species, it has not been possible to dissect all the specimens. Those dissected have their names preceded by an asterisk.

Xyelidæ
- *Macroxyela distincta MacGillivray.

Pamphiliidæ
- *Neurotoma inconspicua (Norton).
- " hortorum Klug.
- Bactroceros plagiata Klug.
- *Pamphilius ocreatus (Say).
- " rufocinctus (Cresson).
- * " silvatica Linnaeus.

Megalodontidæ
- Rhipidiocerus luteiventris Konow.
- Megalodontes cephalotes Klug.
- " orientalis Kirby.
- " plagiocephalus Kirby.
- " spissicornis Klug.
- " victoriosa Dalla
- " Torre.
- Melanopus fabricii Leach.

SIRICIDÆ
Sirex gigas Linneaus.
*Tremex columba Linnaeus.
XIPHYDRIIDÆ
*Xiphydria maculata Say.
Cephidæ
*Cephus pygmaeus Linnaeus.
BLASTICOTOMIDÆ
Blasticotoma filiceti Klug.
CIMBICIDÆ
*Cimbex americana Leach.
TENTHREDINIDÆ
*Dolerus bicolor Beauvois.
*Croesus latitarsus Norton.
ARGIDÆ
Arge ciliaris Linnaeus.
ORYSSIDÆ
*Oryssus sayi Westwood.
BRACONIDÆ
*Bracon vulgaris Ashmead.
ICHNEUMONIDÆ
*Ephialtes conquisitor (Say).
MEGALYRIDÆ
Megalyra fasciipennis Westwood.
TRIGONALIDÆ
*Tapinogonalos pulchellus Cresson.
AULACIDÆ
Pammegischia xiphydriæ Ashmead.
*Odontaulacus editus Cresson.
Oleisoprister stigmaterus Cresson.
Neaulacus occidentalis Cresson.
STEPHANIDÆ
Stephanus sp.
*Hemistephanus sp.
FOENIDÆ
Foenus affector Linnaeus.
* " incertus Cresson.
" rugulosum Abeille.
" tarsatorius Say.
" thomsoni Schletterer.
" visaliæ Bradley.
MONOMACHIDÆ
Monomachus klugii Westwood.
ROPRONIIDÆ
Ropronia garmani Ashmead.
HELORIDÆ
Helorus anomalipes Provancher.
* " paradoxus Provancher.
VANHORNIIDÆ
Vanhornia euchnemidarum Crawford.
BELYTIDÆ
Belyta sp.
Serphidæ
*Dolichotrypes hopkinsi Ashmead.
CALLICERATIDÆ
Ceraphron melanocerus Ashmead.
Trichosteresis punctipennis Kieffer.
SCELIONIDÆ
*Telenomus clisiocampæ Ashmead.
Platygasteridæ
Platygaster sp.
PELECINIDÆ
*Pelecinus polyturator Drury.
CYNIPIDÆ
*Cynips poculum Osten Sacken.
CHALICIDIDÆ
*Perilampus subcarinatus Crawford.
*Tetrastichus malacosomæ Girault.
*Ooencyrtus clisiocampæ Ashmead.
EVANIIDÆ
*Evania princeps Westwood.
" urbana Bradley.
PSAMMOCHARIDÆ
*Pepsis sp.
*Ceropales bipunctata Say.
*Psammochares sp.
EMBOLEMIDÆ
Embolemus ruddii Westwood.
CLEPTIDÆ
*Cleptes semiaurata Linnaeus.
CHRYSIDIDÆ
*Tetrachrysis nitidula Fabricius.
PLUMARIIDÆ
*Plumarius sp.
Anthoboscidæ
*Anthobosca chiliensis (Saussure).
SAPYGIDÆ
Sapyga clavicornis Linnaeus.
THYNNIDÆ
Ornepetes silvicola Bradley.
TIPHIIDÆ
*Tiphia inornata Say.
*Epomidiopteron julii Romand.
*Elis quinquefasciata (Fabricius).
*Myzine abdominalis (Guérin).
*Methoca sp.
*Myrmosa unicolor Say.
MUTILLIDÆ
*Dasymutilla occidentalis Linnaeus.
*Brachycystis sp.
*Chyphotes sp.
SCOLIIDÆ
*Scolia dubia Say.
Formicidæ
*Pachycondyla harpax (Fabricius).
BETHYLIDÆ
*Pristocera atra Klug.
Rhopalosomidæ
*Rhopalosoma poeyi Cresson.
VESPIDÆ
*Euparagia scutellaris Cresson.
*Paragia tricolor Smith.
*Ceramius fonscolombei Latreille.
*Paraceraminus lusitanicus (Klug).
Jugurthia oraniensis Lepeletier.
*Trimeria buyssoni Brethes.
*Celonites abbreviatus (Villers).
*Masaris vespiformis Latreille.
Pseudomasaris vespoides (Cresson).

Quartinia major Kohl.
Rhaphidoglossa eumenoides Saunders.
Labus spiniger Saussure.
*Zethus spinipes Say.
Didymogastra aurulens Saussure.
Discoelus verreauxi Saussure.
*Eumenes fraterna Say.
*Pachymenes pallidepes Olivier.
Montezumia azurescens Spinola.
*Monobia quadridens Linnaeus.
Abispa ephippium Fabricius.
*Synagris analis Saussure.
Nortonia intermedia Saussure.
*Rhynchium histrionicum Gerstaecker.
*Odynerus capra Saussure.
*Ancistrocerus clarazianus Saussure.
Symmorphus elegans Herrich-Schaeffer.
Hoplomerus spinipes Linnaeus.
Pterochilus quinquefasciatus Say.
Alastor brasiliensis Saussure.
Vespa affinis Fabricius.
analis Fabricius.
auraria Smith.
austriaca Panzer.
basalis Smith.
bellicosa Saussure.
bicolor Fabricius.
borealis Kirby
carolina Linnaeus.
cincta Fabricius.
communis Saussure.
consobrina Linnaeus.
crabro Linnaeus.
crabroformis Smith.
* diabolica Saussure.
ducalis Smith.
fervida Smith.
germanica Fabricius.
japonica Saussure.
* maculata Linnaeus.
mandarina Smith.
media Retzius.
norvegica Fabricius.
occidentalis Cresson.
orientalis Linnaeus.
parallela André.
rufa Linnaeus.
saxonica Fabricius.
silvestris Scopoli.
sulphurea Saussure.
velutina Lepeletier.
vidua Saussure.
vulgaris Linnaeus.
*Polistes pallipes Lepeletier.
*Icaria cincta Lepeletier.
*Polybia occidentalis var. ruficeps Schrottky.
*Protopolybia sedula Saussure.
*Metapolybia pediculata Saussure.
*Parapolybia occidentalis Olivier.
*Gymnopolybia vicina Saussure.
*Rhopalidia angulata Fabricius.
*Stelopolybia rejecta Fabricius.
Polyboides tabida Fabricius.
*Belonogaster grisea Fabricius.
*Apoica pallida Olivier.
Synoeca surinama Linnaeus.
Epipona tatua Cuvier.
*Mischocyttarus labiatus Fabricius.
*Chartergus chartarius Olivier.
Parachartergus apicalis Fabricius.
*Nectarina augusti var quinta von Ihering.
*Protonectarina sylveirae (Saussure).
Caba lecheguana (Latreille).
*Megacanthopus cassununga Ihering.
*Myrapetra aequatorialis von Zavattari.

AMPULICIDÆ
*Ampulex compressus Fabricius.
*Dolichurus stantoni (Ashmead).

DRYINIDÆ
Chelogynus henshawi Ashmead.

SPHECIDÆ
*Astata unicolor Say.
*Larra analis Fabricius.
*Trypoxylon albitarse Fabricius.
*Sphex nigricans Dahlbom.
*Mimesa pauper Packard.
*Bembex spinolæ Lepeletier.
*Crabro interruptus Lepeletier.

HYLAEIDÆ
Hylaeus modestus (Say).
*Colletes guadialis Cockerell.

ANDRENIDÆ
*Halictus poeyi Lepeletier.
*Andrena vicina Smith.
*Nomada bella Cresson.
*Eucera grisea Fabricius.
*Xylocopa virginica Drury.
*Ceratina dupla Say.

MEGACHILIDÆ
*Osmia lignaria Say.
*Megachile infragilis Cresson.

Euglossidæ
Euglossa cordata Linnaeus.

Bombidæ
*Bombus pennsylvanicus Degeer.
*Psithyrus labriosus Fabricius.

APIDÆ
*Apis mellifera Linnaeus.

MELIPONIDÆ
Melipona interrupta Latreille.

LITERATURE CITED.

Boerner, Carl. Stammesgeschichte der Haütflugler. Biologisches Zentralblatt. 1919. 39 : 145–186.

Comstock, John Henry. Synopsis of the Hymenoptera. (*In his* An introduction to entomology. Ithaca, The Comstock Publishing Co., 1924. p. 890–891.)

Comstock, John Henry and **Kellogg, Vernon L.** Mouth-parts of the white-faced hornet. (*In their* The elements of insect anatomy. Ithaca, The Comstock Publishing Co., 1918. p. 75–77.)

MacGillivray, Alex. D. Hymenopterous maxillæ and labia. (*In his* External insect-anatomy. Urbana, Scarab Co., 1923. p. 120–127.)

Maidl, Frantz. Monographie der Gattung Synagris Latrelle (Hymen.-Vespidae). Denkschriften der kaiserlichen Akademie der Wissenschaften, math.-naturw. Klasse. 1914 (1915). 91 : 224.

Snodgrass, R. E. The anatomy of the honey bee. U. S. Bureau of Entomology. Tech. ser. Bul. 18 : 43–46. 1910.

EXPLANATION OF PLATE XXXIV.

Fig. 1. An acroglossal button of *Vespa maculata* showing s, the sensory setae, the number of which varies from 8–10 on each button in this species.

Fig. 2. Glossa of *V. maculata*, with the caudal surface removed, showing m, the muscular strand connecting the acroglossal button with the base of the glossa.

Fig. 3. Caudal view of glossa of *V. maculata* showing a, the acroglossal button.

Fig. 4. Flabellum of *Psithyrus laboriosus*.

Fig. 5. Portion of glossa of *Apis mellifera* showing c, the terminal chitin band; s, the sensory setae, and f, the flabellum.

Fig. 6. Submentum and mentum of *Periplanata americana*. Note large submentum (sm).

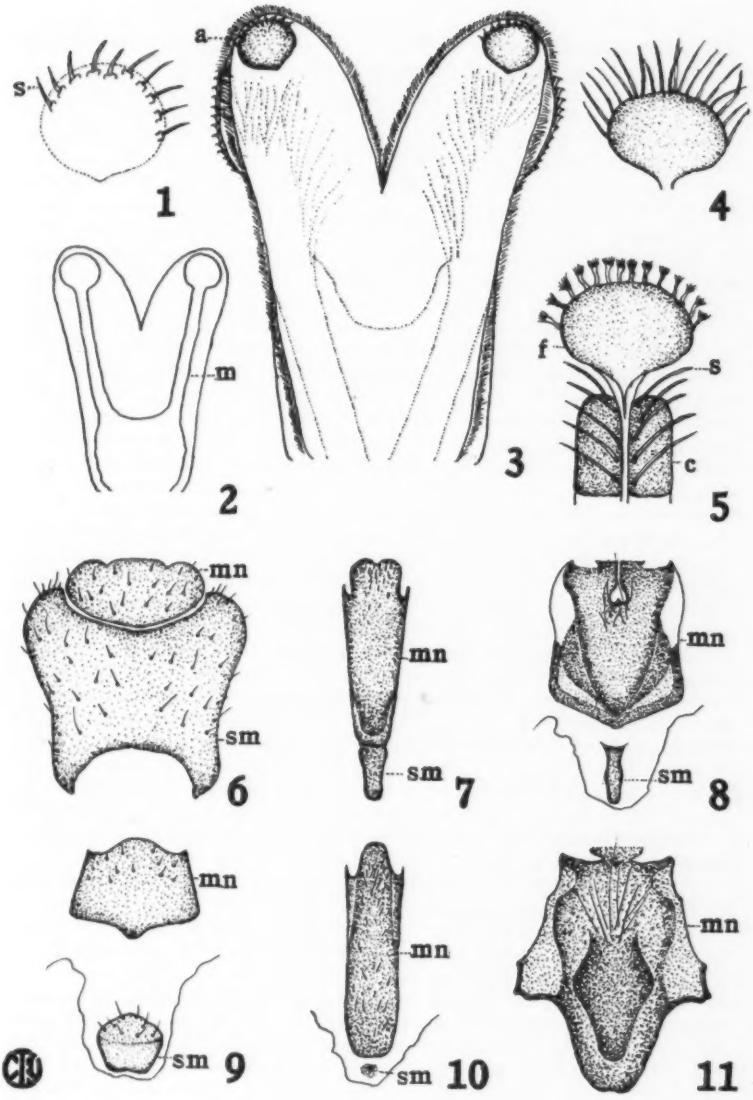
Fig. 7. Submentum and mentum of *Plumaris* sp. Note separation between submentum and mentum (mn) only by a suture.

Fig. 8. Submentum and mentum of *Psammochares* sp. Note separation between submentum and mentum.

Fig. 9. Submentum and mentum of *Dolerus bicolor*. Note wider separation between the two structures.

Fig. 10. Submentum and mentum of *Megalodontes orientalis*. Note indefinite boundary of submentum.

Fig. 11. Mentum of *Vespa maculata*. Submentum is atrophied.



C. L. Lin

NOTES ON SOME TYPES OF AMERICAN MUSCOID DIPTERA IN THE COLLECTION OF THE VIENNA NATURAL HISTORY MUSEUM.

J. M. ALDRICH,
United States National Museum.

(Continued from Vol. XVIII, p. 130).

61. *Paralucilia fulvipes* Blanchard. A male and female so labelled on the same pin; also labelled "Chili Coll. Winthem." and "fulvipes det. B. B."

The genus was established by Brauer and Bergenstamm in 1891, page 391, in the following words (translation): "*Musca* (*Calliph.*) *fulvipes* (Blanch. S.) forms a new genus near Lucilia. Third vein setulose only at the base. *Paralucilia*, n. Chile." Brauer afterward (Sitzungber Kais. Akad., Vol. CIV, 1895, 599) attempted to explain the material on which the determination of *fulvipes* was made. Schiner, he said, confused two species, a male and female on the same pin (referring to the same specimens now under discussion), which were supposed to be of the same species but were not. He also says the genus was based on the female of the two and on a MS. species from Amboina. The oriental species may be disregarded however, as nothing was said originally about any species except *fulvipes*. Schiner, as appears in Novara, 309, 1868, had a type of *fulvipes* from Macquart, and 3 other specimens, in which the middle and hind femora were yellow in the middle. Brauer, 1895, must have seen other specimens than the pair on one pin, as he says the male *sometimes* has enlarged eyes. Neither of the specimens before me belongs to *fulvipes*, but apparently they were incorrectly associated with it by Schiner. It seems to me too late, in 1895, to attempt to limit the genus Paralucilia to a different species than *fulvipes*. Townsend in Ins. Ins. Menst., Vol. IV, 1916, page 11, proposes the name *Paralucilia braueri* for the female specimen misidentified by Brauer and Bergenstamm as *fulvipes*, but Brauer and Bergenstamm presumably had one or more of the true *fulvipes* before them in Schiner's material; so I disregard Brauer's 1895 note.

The only difficulty I see about the type designation in Paralucilia is that the species *fulvipes* is attributed to Blanchard instead of Macquart; but as Blanchard redescribed the species there is no doubt at all about the intention; moreover his description agrees precisely with the original by Macquart.

Returning to the specimens above mentioned, labelled *Paralucilia fulvipes* Blanchard, the female, which is above on the pin, is *Chrysomyia desvoidyi* Hough, although the vibrissæ are somewhat nearer the oral margin than in all of the specimens in the National Museum; the hind calypter is hairy on the disk on the mesal side; the palpi are normal; the dorsocentrals are present although small; the mesonotal pollinose

stripes are very feeble; the femora are hairy, black. I have recently described the species.* According to my determination *braueri* Townsend is a synonym of *desvoidyi* Hough. The male on the same pin has the vibrissæ much higher above the mouth; palpi normal; no dorsocentrals except two or three close to scutellum; disk of hind calypter entirely bare; mesonotal stripes strongly developed; and an area of strikingly large facets in the front of the compound eyes, comprising about half the eye as viewed from in front; they are approximately as large as the front ocellus, and the eyes resemble those of a male Tabanid. The middle and hind femora are yellow on the middle half, or thereabouts; the front femora with a yellowish streak on the hind side for the whole length. Length 8 mm. I do not find in the literature any references to such eyes as this male possesses, but it is probably a described species. It is not in the National Museum.

62. *Paradoria nigra* Brauer and Bergenstamm (1891, 339). Three males, cotypes, "Lindig. Venez. 1864"; one additional male, "America," not a type. I am permitted to retain one cotype in exchange as the species has not been heretofore represented in the National Museum. This is the type species of Paradoria, which I find to be a synonym of Paralispe Brauer and Bergenstamm, as I suspected. *Nigra* is much smaller than *brasiliana* Brauer and Bergenstamm, the genotype of Paralispe, but structurally almost the same, only lacking the discals on the second and third abdominal segments.

Male.—Eyes densely hairy; front rather narrow (.21 of head), one pair of verticals, large and reclinate; no ocellars; two pairs large proclinate orbitals; three upper frontal pairs large and reclinate, the third smaller, the rest curved inward and smaller; lowest at level of arista, almost meeting bristles of facial ridges. The parafrontals are brown at vertex becoming lead colored or subsilvery at the middle. Antennæ black, slender; third joint hardly three times the second, slender; arista distinctly pubescent under low power, the penultimate joint short. Palpi blackish or perhaps very dark yellow, of about normal size but rather retracted in all the specimens. Bucca about one-seventh the eye height. Parafacials a little narrower than third antennal joint. Dorsocentrals 3. Abdomen mostly subshining black, the very narrow base of the second segment ashy pollinose, widening each side of a middle black stripe; third segment the same but with wider anterior band; fourth segment more pollinose at the sides on the anterior half, less in the submedian spots; the effect is a median stripe indistinctly outlined by the adjacent lightly pollinose spots.

Front tibia with one posterior outer bristle; middle tibia with one bristle on outer front side; hind tibia with a row of rather long and even but not crowded bristles, scutellum with two erect small apicals, the last lateral pair long, reaching to third segment; an intermediate lateral smaller and a basal nearly as large as the subapical.

63. *Paragymnomma hystrix* Brauer and Bergenstamm (1891, 384). Three males, two are labelled "Beske 848 Brasilien," the other "Natt.: Brasil: Ypanema." All are types I judge.

*Proc. U. S. Nat. Mus., vol. 66, Art. 18, p. 19, 1925.

One of Beske's specimens has the tip of the abdomen a little mashed in and I took it for a female at first, perhaps Brauer and Bergenstamm did also. It has no orbitals however. Type of the genus Paragymnomma. The genus Gabanimyia Townsend (Ins. Ins. Menst., II, 1914, 44, type *polita* Townsend) is a synonym and I feel reasonably certain that Townsend's species *hystricosa* is a synyonym of *hystrix*, but we have only a female specimen. There are some differences in the antennæ: *hystricosa* has a shorter, more rounded, third antennal joint and longer penultimate joint of the arista, but the correspondence is practically perfect otherwise, especially the seal-brown abdomen with reflection just to the median line from one side, changing to the other half when viewed from the other side. The genus is characterized by having strongly developed spines, no palpi, eyes bare, parafacials pilose and with one large spine on the lower part like those in Peleteria; no ocellars and no spines on abdominal sternites.

64. *Bombyliomyia flavipalpis* Macquart. (Suppl. I, 1846, 275; Brauer and Bergenstamm 1889, 131). Type of genus Bombyliomyia. Two females, one labelled "Coll. Winthem. Brasilia," the other "Schiner 1869"; both also labelled in purple ink, large hand, "*flavipalpis* type B. B." Evidently neither are real types of *flavipalpis*, but probably are correctly identified, and the genus was based on these specimens. They agree with the few data given by Macquart. The species is the one which Townsend described as *Eublepharipeza hystrix* (Ins. Ins. Menst., II, 1914, 46), the type of Eublepharipeza. The head is narrow; the eyes densely hairy; the parafacials narrow, hairy; ocellars absent or hairlike; one pair of very large decussate verticals; two bristles below eye above the peristomial row; scutellum and abdominal segments two to four with a dense mass of erect spines irregularly arranged. Sternites 2–4 with dense spines also. Color black, except the palpi; pollen of the head plumbeous. Third antennal joint slightly oblique in shape, more than twice the second; arista pubescent, its basal joints short.

65. *Phasiophana obsoleta* Brauer and Bergenstamm (1891, 290). One male, "Brasilia. Alte Sammlung." Type of the genus. Stein, Ann. Mus. Nat. Hung., XVI, 1918, 233, has already noted correctly from this type that the genus is a synonym of Myiospila. The species closely resembles *meditabunda*, but the wing (male) is even more wedge-shaped and narrow apically; the small crossvein is infuscated; the hind calypter has a brown rim; the third vein has only one very small hair at base above, two or three larger below. Abdomen too much damaged to get the markings.

66. *Cryptomeigenia setifacies* Brauer and Bergenstamm (1891, 311). One female, "Beske. 150, Brasilien." Type of the genus and species. I am surprised to find that the "setæ" on the face are more delicate than the term would indicate. In fact they are only a little coarser than the hairs occurring in the same place in North American species, which undoubtedly are congeneric. The species has the same elongated body, legs and wings as ours. Coquillett recognized only one North American species, under the name of *theutis* Walker; there are however several species in our fauna, easily distinguishable by the form of the ovipositor

in the female but very difficult to separate in the males. Emphanopteryx and Eumyothyria of Townsend (Trans. Am. Ent. Soc., XIX, 1892, 120 and 121) are both synonyms of Cryptomeigenia. Townsend was in error in describing the latter genus when he stated that the parafacials were bare, as I found from examining the type.

This Brazilian type has no visible ovipositor at all, agreeing with some of our North American specimens in this regard. I looked under the calypters on the sides of the metanotum for the small hairs recently mentioned by Mr. Curran as a new Tachinid character; there are three distinct black hairs on the right side, but none on the left. The apical scutellars are hairlike and symmetrical, one being larger than normal for our northern specimens. There are three pairs of lateral scutellars. There are about 20 black parafacial hairs on one side and 25 on the other, below the lowest frontal. The rather full description by Brauer and Bergenstamm will suffice for the remainder.

67. *Pseudoviviania platypoda* Brauer and Bergenstamm (1891, 311). One female, type, "Lindig 1864, Venez." Type of the genus. A synonym is *Minthopsis vittata* Townsend (Proc. U. S. N. M., 49, 1915, 417), from Peru; types compared. This is one of several South American muscoids which has a strikingly striped thorax, there being a narrow median white stripe, expanding behind to include most of the scutellum, and a broader one on each side from the humerus, passing above the wing to the corner of the scutellum. The intervening part of the mesonotum is deep black on each side of the middle. The abdomen is tessellated and densely covered with yellowish-gray pollen. Fourth vein with rounded bend, joining the third at the margin a little before the apex; third vein with two to three hairs at base. Underneath the lower calypter are six or eight distinct black hairs on each side. Middle and hind femora yellow on basal two-thirds, the front one indistinctly yellow on inner side on basal half; a single large pair of presutural acrostichals; dorsocentrals 2, 3.

68. *Selenomyia brevicornis* Brauer and Bergenstamm (1891, 361; 1893, 170). One male, "Philippi, Chili, 1870." The species is attributed to Philippi, but he did not describe it. The specimen had lost the proboscis before Brauer and Bergenstamm described it and is now in poor condition, the third joint being gone from both antennae, the genitalia eaten out, and the hind legs missing; the abdomen is unskilfully glued on, hiding the region of the postscutellum, although this protuberance apparently shows a little on one side. The species is not found in the National Museum. The full description given by Brauer and Bergenstamm should make this recognizable in material from Chile. The abdomen has very characteristic paired glaucous lunules on the flattened dorsum of the second and third segments. The head looks much like a male Calliphora, except in having deep, short antennal grooves with a sharp keel between. The front is only .055 of the head-width, about equal to the ocellar triangle. Along its narrowest part there are no frontal bristles. Between the base of the antennae and the eye, on each side, is a somewhat swollen space with a large striking changeable blackish spot. The frontals extend only to the base of the

antennae. The parafacials and eye are bare. Verticals one pair, slender. Thorax with very slender, hairlike bristles. Dorsocentral 2, 4; acrostichal 3, 3; sternopleural 2, 1; calypters bare, white, the hind one large; hypopleurals numerous, large. Front and middle femora slender, black; claws and pulvilli long; front tibiae yellowish, with one outer bristle; mid tibia yellow, slender, curved, with two bristles each on outer front and outer hind side. Bucca more than half the eyeheight, the beard yellow below the metacephalic suture, black elsewhere.

69. *Sisyropa vorax* Wiedemann, (Auss. Zw., II, 1830, 315 *Tachina*); Bigot, Annales, 1888, 258 (*Chaetolyga flavolimbata*); Brauer, Sitzber. k. Akad., CVI, 1897, 23, note on Bigot's type and synonomy). Three males, each labelled, "Vorax det. B. B."; two are "Mexico," the other "Bilimek Mex. 1871 Orizaba, Novbr." This is an authentic determination, I dare say. On going through the National Museum collection I found three males of the same species; on spreading the genitalia of these and also of the Vienna specimens of *vorax* I find them to be undoubtedly the same species and quite characteristic. Our specimens are from Porto Bello, Panama, collected by August Busck, February 25, and March 14 and 23, 1911. The species thus become technically a North American one.

Male.—Front narrow, .21 of headwidth (.21, .21, .20), widening rapidly toward the antennae; parafrontals and parafacials deep golden yellow pollinose; one pair verticals; ocellars present, proclinate; frontals about eleven pairs, only one reclinate, which is some distance from the next. Lowest four diverging below root of antennae, reaching to level of arista. Vibrissae at edge of mouth, smaller than usual, only four to five hairs above them; ridges quite flat and bare farther up. Antennae black, third joint twice the second and reaching well toward vibrissae; arista only a little thickened on basal third, its penultimate joint short. Bucca hardly one-fifth the eyeheight. Palpi black, normal; proboscis small. Beard deep yellow above, paler below. Eyes densely hairy.

Thorax with three black stripes, the submedian gray ones also narrowly divided when viewed from behind. Dorsocentral 3, 4; acrostichal 3, 3; humeral 5; posthumeral 2; presutural 2, the inner one small; notopleural 2; supraalar 3; intraalar 3; postalar 2; scutellum with three lateral, one decussate apical, one small discal; sternopleural 3; pteropleural 1, small.

Abdomen gray pollinose, gradually thinner on hind part of segments, which become subshining in some lights and faintly bordered with brown. First and second segments with one pair of median marginals, third with rather dense row of 12 marginal bristles, fourth with a row at one-third its length from the hind border and another smaller at the margin. Venter without any brushes, fifth sternite concealed, genitalic segments black; inner forceps united, long, evenly tapered, straight, sharp; outer forceps of similar shape and length, giving the effect of three organs just alike. Penis small, goblet-shaped. Legs black, front tibia with two bristles behind, middle tibia with three bristles on outer front side, the upper small, the lower very long; inner surface of middle tibia subvillous, but the hair short. Hind tibia not villous,

with cilia on the outer side which are quite even, but one much longer stands below the middle. Claws and pulvilli long, less so on hind tarsi.

Wings slightly infuscated, fourth vein with short bend, concave to costa, ending well before tip; third vein with four to seven hairs.

Length, 8.5 to 9.5 mm.

This species I would think be congeneric with *Exorista confinis* Fallen, which has been referred to Zenillia by Aldrich and Webber, 1924.

70. *Chaetoprocta tarsalis* Schiner (*Blepharipeza tarsalis* Schiner, Novara, 1868, 336; Chaetoprocta Brauer and Bergenstamm, 1891, 341; 1893, 120). On account of the preoccupation of Chaetoprocta, Townsend has proposed to substitute Pterotopeza, new name, in Muscoid Flies, 1908, p. 113. One male, "Lindig 1864, Venezuela," undoubted type of Schiner's species, which is the genotype of Chaetoprocta Brauer and Bergenstamm. There is no specimen of this species in the National Museum, but Townsend's Jaenimyia (Proc. U. S. N. M., 43, 1912, 350, from Peru), while founded on a different species (*albicincta* Townsend) is, I think, a synonym. Townsend's second species, *punctata*, is more closely related to *tarsalis* then his genotype.

Male.—Front .30 of headwidth, widening rapidly from above middle; no ocellars; one pair of verticals, stout; only one small frontal is reclinate, the next some distance forward is knocked off, but from the scar must have been very small; eight more anterior to this; orbitals absent. Upper part of front about vertex with dense erect hair. Antennae black, third joint less than twice the second. Arista with distinct but short penultimate joint. Parafacial with fairly conspicuous dark hairs down to the transverse impression. Facial ridges bare, only two small bristles above vibrissae. Bucca about two-thirds the eyeheight; palpi blackish, stout but not long; back of head below with bushy white hair. Thorax and abdomen with bluish pollen, the former with five black stripes before the suture when viewed from behind, the median one, however, not visible from the front; it only extends to the suture and the submedian ones a little farther, while the interrupted lateral ones reach almost to the corners of the scutellum; acrostichal 3, 2; dorsocentral 2, 4; humeral 2; posthumeral 1; presutural 1, and an almost imperceptible hairlike inner one; notopleural 2; supraalar 3; intraalar 2 (far back); scutellum with four pairs of normal reclinate marginals and an apical group of eight suberect spines, the central one smaller; also with two pairs of erect, short, spiny discals; sternopleural 2; pteropleural 0. Just posterior to the outer postalar bristle there is a strong tuft of long black hairs curving backward. The pteropleura also has a much larger and denser brush of similar hairs; the hypopleural bristles are hairlike, very numerous and not arranged in a row. The bristles on the coxae become much more spine-like on the middle and hind ones, where they are quite striking. Abdomen almost wholly pollinose above beyond the first segment, the hind margins in some lights more blackish; the abdomen is very broad and the apical mass of black hairs is very striking. First segment without median marginals; second segment with unsymmetrical and irregular marginal row of six spines as well as

two stout at the side, separated by a considerable space; third segment with several stout spines mixed with hairs at the side, and an irregular marginal row of spines extending clear across; fourth segment with no spines, but only dense long hairs beginning before the middle on the upper side; below they begin on the preceding segment near its base. Venter with conspicuous interrupted whitish bands on the second and third segments and very striking median cluster of spines on segments one to three, which are situated in part on the ends of the tergites and in part on the sternites. Genitalia small, of rather unspecialized type, the fifth sternite having a deep cleft which is rounded at base. Legs black, the front and middle tibia yellow, middle tibia with four or five bristles on outer front side; hind tibia with a striking row of dense, even, slightly flattened bristles on the outer side which are nearly twice as long as the thickness of the tibia; front and middle claws and pulvilli not much elongated, yellow, only the tips of the claws black.

Wings deep brown, fourth vein slightly oblique at bend, nearly straight to costa, ending only a little before the extreme tip of the wing, the distance before hardly more than the preceding costal segment. Length, 12.5 mm., without the abdominal tuft of hairs.

71. *Thysanomyia fimbriata* Van der Wulp (*Brachycoma fimbriata* Van der Wulp, Biologia, II, 1890, 97; Brauer and Bergenstamm, 1891, 340; 1893, 121). The material is in three lots as follows:

(a) One male, one female; the former labelled "*Thysanomyia fimbriata* V. d. W.," both labelled "Beske 848, Brasilien." These have yellow palpi and first and second antennal joint and run to *biseriata* in Van der Wulp's table of *Brachycoma*. I do not consider these to be the true *fimbriata*.

(b) One male, labelled "*fimbriata* V. d. W. det. B. B.," "Beske 155 Brasilien," runs to *fimbriata* in the Van der Wulp table of Brachycoma and is the same as a male specimen from Costa Rica (Schild and Burgdorf) that Coquillett had determined as *fimbriata*. This I provisionally regard as correctly named, although Van der Wulp probably had at least two species under the name.

(c) One male labelled "*fimbriata* V. d. W. det. B. B.;" the locality is a few letters illegibly written looking like "pocp-112." This is a third species, differing at a glance from the preceding two in lacking the spots of matted hair below on the third tergite which both the others have. Not having an actual type among these, I will have to let the species rest until the material in the British Museum can be carefully examined.

72. *Macromeigenia chrysoprocta* Wiedemann (described as *Tachina*, Auss. Zw., II, 1830, 309, without locality; Brauer and Bergenstamm 1891, 311; 1893, 111). One female labelled "F. b." in very nice script and bearing a very old label as type of *chrysoprocta*. Type of the genus.

This is identical with our common species so identified and needs no description. I would add, however, that the old label referred to bears a very distinct interrogation point; in spite of this I feel tolerably sure that this is the real type.

73. *Gaediophana atra* Brauer and Bergenstamm 1893, 201. One female, Mexico, marked type; also type of genus. There are 12 specimens of this species in the National Museum; one male from White Mountains, New Mexico, identified by Townsend, but with the word "sub. sp." added. Other specimens are from Brownsville and Brewster County, Texas; Mexico City; Chihuahua; Antiqua, Guatamala; and Irazu, Costa Rica. A robust, black species, easily recognizable from the description, having hairy eyes and broad, hairy parafacials; facial ridges bristly about to the arista, which has a long penultimate joint. The type has a large scar of an ocellar bristle on the left side, none on the right; and the ocellars are absent in all but two of our series.

The abdomen in the type has numerous, erect, bristly hairs and small bristles along the middle portion tending toward what would be called discal bristles. Sternopleurals 4.

74. *Paragaedia hedemanni* Brauer and Bergenstamm (1891, 350; 1893, 123). One female, "Hedemann, Mexico, 1868," and one male, "Bilimek, Mex. 1871. Takubaya." The female is the type, and the species is the type of Paragaedia. Brauer stated (Sitzungsber. Kais. Akad., CVI, 1897, 348), that *hedemanni* is a synonym of *cyaneiventris* Macquart (described as Blepharipeza, Dipt. Exot., Suppl. I, 1846, 285), on the basis of a supposed Macquart type which he saw in the Bigot collection. It would appear that one of two errors occurred; the Bigot specimen was not correctly identified, or possibly he compared the above-mentioned male instead of the type female, the male belonging to a different but congeneric species from *hedemanni*. The former is the more plausible hypothesis. At any rate Macquart says that *cyaneiventris* has a black thorax with yellowish pollen and a blue abdomen, while the type of *hedemanni* has a bluish thorax and an entirely black abdomen. The male labelled as *hedemanni* in the Vienna material comes somewhat nearer to *cyaneiventris*, but appears not to agree with the description.

In the U. S. National Museum there is a male from Uruhuasi, Peru, determined by Townsend as *Chaetoprosopa cyanea*, a Brazilian species, type of Chaetoprosopa, described by Macquart in Dipt. Exot., Suppl. IV, 1851, 169. This I believe is correctly identified, and is strictly congeneric with both the Vienna specimens. This would make Paragaedia a synonym of Chaetoprosopa Macquart.

There are also in the National Museum three males of *hedemanni*, reared by James Zetek at Frijoles, Panama, from the larvae of the moth *Xylomyges eridania* Cramer (Z-2441).

The generic characters of Chaetogaedia as given by Brauer and Bergenstamm 1891 serve for Chaetoprosopa, except for one palpable mistake. The expression "Hinterleib dicht kurz-borstig" must have been derived from looking at some other fly, as there are no such dense, short bristles on the abdomen of *hedemanni* nor the accompanying male. In both, as well as in Townsend's identification of *cyanea*, the abdomen has on the second segment neither discals nor marginals, and only a row of marginals on the third, the whole disk of the abdomen being covered only with smooth, appressed hair, as in the smoothest

specimens of *Parachaeta inermis* Bigot, which in spite of the absence of the row of parafacial bristles is obviously a near relative. This row of bristles, continuing from the frontals without interruption, is one of the main characters of Chaetoprosopa. Others that may be noted are absence of ocellars, only one vertical, only one frontal reclinate, eyes bare, third joint of antennae less than twice the second, the basal joints of arista short. Facial ridges bristly almost to arista. Otherwise similar to Blepharipeza, including the heavy fringe on hind tibiae.

If *cyaneiventris* belongs to this genus, as seems very likely, there must be at least four species, of which three are before me. They may be tabulated as follows:

KEY TO SPECIES OF CHAETOPROSOPA.

1. Abdomen with faint, pale pollen on anterior part of second and third segments; which is broadly interrupted in the middle, giving the effect of a median broad black stripe; head with white pollen, silvery on posterior orbits. *cyanea* Macquart.
   Abdomen with faint pale pollen as in preceding, but scarcely interrupted at all in middle; pollen of head golden..... *auriceps* new species
   Abdomen without any pale pollen on dorsum.....2
2. Abdomen deep black, only when viewed from behind with faint seal-brown reflection..... *hedemanni* Brauer and Bergenstamm.
   Abdomen blue..... *cyaneiventris* Macquart

The character given in the key for *cyanea* was not mentioned by Macquart, but might easily have been overlooked by him; I take it from Townsend's specimen.

On the original data and the note by Brauer connecting it with *hedemanni*, I venture to include *cyaneiventris* Macquart.

Chaetoprosopa auriceps new species.

Male.—Length, 10.5 mm. Width of front at vertex, .23 of head-width. Front with dense, erect hair, no ocellars; vertical and the single pair of reclinate frontals rather small. Parafrontals except near vertex golden, face and posterior orbits also golden. Frontal rows crowded and partly doubled, also crowded where they descend on the parafacials; many small hairs between these and the eye all the way. Antennae red about to arista. Thorax with glaucous pollen; scutellum reddish, with three lateral and a single discal pair, apicals hairlike. Abdomen with bluish cast, the thin pollen of dorsum becoming denser below, where it forms a very distinct, large spot on second segment. Wings blackened to tip of basal cells, the rest subhyaline. Calypters infuscated.

One male, Takubaya, Mexico (Bilimek, 1871), identified by Brauer and Bergenstamm as *Paragaedia hedemanni*. Type in Vienna Museum.

75. *Hypotachina disparata* Brauer and Bergenstamm (1891, 351; 1893, 124). One male, "Brasilien," undoubted type; type of genus also. In the National Museum I found two males of this species from Peru, identified by Townsend as Phyllolabella species. This genus was established by Townsend in Ins. Ins. Menst., VI, 1918, 168, the type and sole species being *robusta* Townsend, from Brazil. This species was

described from a single pair belonging to the American Museum in New York, to which the types have been returned. It seems fairly clear from the description that these specimens all belong to ***robusta***, therefore, I consider this species a synonym of ***Hypotachina disparata***. The only difference between the Brauer and Bergenstamm type and the other specimens is that the former has deep golden pollen on the front and face where it is only light golden in the Peruvian specimens. One female from Panama I think is also the same species.

Male.—Front very narrow above, .11 of head width; eyes densely pollinose; bucca two-fifths of eye height. One pair verticals; one pair proclinate ocellars; a dense row of erect frontals beginning a little before the ocellus, but none reclinate, the lowest reaching the level of the middle of the second antennal joint. Antennæ black, third joint somewhat pear-shaped, not very long (about one and two-thirds times the second); facial ridges with a heavy black stripe, somewhat raised above clypeus, and with erect bristles to the level of the arista. Orbits deep golden all the way round the eye; palpi and proboscis normal, the former dark reddish. Thoracic chætotaxy: acrostichal 3, 3; dorsocentral 3, 3; humeral 5; posthumeral 2; presutural 1 (very large, far forward); notopleural 2; supraalar 4; intraalar 3; postalar 2; scutellum with three marginal pairs of large, no small apicals, and one discal pair; sternopleural 2; pteropleural 0; hypopleural a row of stout bristles and a patch of hairs bordering them anteriorly. Abdomen with very distinct stripes as described by Townsend, with one pair of large discals on second and third; one pair marginal on second with a lateral on each side; third segment with one pair marginal and two lateral each side; fourth with two rows of erect bristles. Genitalia small, genital segments red, inner forceps united into a small, shining, black, straight dagger; outer forceps little curved in apically, slender, bare, longer than inner. The second, third and fourth sternites with a few long, erect hairs at tip, none on inflexed ends of the tergites; fifth sternite with prominent lobes.

Legs black, claws and pulvilli long, (middle legs missing), hind tibia with four bristles on outer hind side, smaller above, with a row of long hairs between. Two to three bristles on inner hind side near middle.

Wings distinctly brownish, especially on the veins, fourth with distinct, long appendage at bend, ending considerably before apex, the hind crossvein only a little before the angle; the third vein with six to seven hairs close together at base.

76. *Exorista optica* Schiner (Novara, 1868, 327; *Parexorista* Brauer and Bergenst amm, 1891, 400). One female with what appears to be the Schiner type label and also the Brauer and Bergenstamm type label "Novara R. Brasilia," agrees with Schiner quite well, but the third antennal joint is only four times the second, not six times as he says. I believe, however, that this is the true type.

Belongs to Eumasicera, if this genus is distinct, which seems doubtful after examining several species in our collection; at any rate ***optica*** is a close relative of ***sternalis***, genotype of Eumasicera. The type of ***optica*** runs to ***sternalis*** in the table of Zenillia by Aldrich and Webber.

As in *sternalis* the anterior large, reclinate frontal is situated half-way between the vertical and the lunule and the front is quite flattened—not at all prominent. *Sternalis* female has more dense and uniform yellowish pollen on the abdomen than *optica*. There is one male of *optica* in the National Museum, collected at Rurrenabaque, Beni, Bolivia, by Doctor Wm. M. Mann, on the Mulford Biological Exploration.

Female.—(Type) Front .28 of headwidth. Arista slender with a little delicate pubescence on basal half; third antennal joint slender; eyes hairy; outer vertical small; ocellars large, proclinate; two reclinate frontals, the second largest. Below this only six smaller bristles (on one side five), the lowest hardly at tip of second antennal joint. Parafacials silvery, somewhat narrower below than the third antennal joint; vibrissæ at mouth, not approximated; two to three hairs on facial ridge; palpi yellow. Bucca one-eighth the eyeheight. Thorax gray with indistinct stripes. Chætotaxy: acrostichal 3, 3; dorsocentral 3, 4; humeral 4; posthumeral 2; presutural 2 (inner rather large); notopleural 2; supraalar 3, large; intraalar 3; postalar 2, large; scutellum with 3 lateral, one rather large apical (over half as long as adjacent lateral); 1 discal; sternopleural 3; pteropleural 1, small; no minute hairs under calypter. Abdomen with ill-defined pollinose cross-bands about as wide as darker hind border of segments; first segment with one small pair of median marginals; second segment with one large pair of median marginals; third segment with row of eight; fourth segment with discal row of six smaller and almost no marginals. Legs black, middle tibia with one bristle on outer front side. Wings hyaline, third vein with two to three hairs at base.

Length—8.6 mm.

77. *Ptilozeuxia brevicornis* Wiedemann (*Tachina brevicornis* Wiedemann, Auss. Zweifl., II, 1830, 299, from Montevideo; Brauer and Bergenstamm 1891, 368). One male, labelled "Montevideo," also bearing an old label in faded brown ink "brevicornis Wiedemann Montevideo." Agrees exactly with Wiedemann's description.

The genus Ptilozeuxia was based on *Dexia brevicornis* Egger, a European species with discal and marginal abdominal bristles, three sternopleurals, etc. From Egger's description of this species and the recently published one by Stein (Arch. f. Naturgesch., 90, 1924, 236) it is clear that Wiedemann's species is not congeneric and I therefore propose to make it the type of

Mallonotum, new genus.

A muscoid genus with hypopleurals and apical crossvein but without postscutellum; arista subplumose basally, bare on apical half. Belongs in Sarcophagidæ, having considerable resemblance to Sarothromyia, but with very different chætotaxy and somewhat less development of the lower back part of the head. There is but one sternopleural (posterior). The abdomen bears only two pairs of bristles, one lateral on first segment and one median marginal on third. The pleuræ, entire abdomen and femora are covered with erect dense soft hair which is more furry than woolly. Genotype, *Tachina brevicornis* Wiedemann.

Mallonotum brevicornis Wiedemann.

Male.—Almost wholly yellowish-gray pollinose, the thoracic dorsum with two dark, indefinite changeable stripes. The dorsum of abdomen with vague darker area on disk tending toward paired faint spots on third and fourth segments. Ground color wholly black, the antennæ and palpi the same; frontal stripe reddish anteriorly.

Front broad, .44 of the headwidth; parafrontals yellowish-gray pollinose, wider than the median stripe; ocellars normal; verticals two pairs; orbitals two pairs, proclinate; frontals six or seven, barely descending below origin of antennæ, the upper pair larger, reclinate, near the eyes. Parafacials of same color, wide with numerous delicate hairs which tend to form a diagonal row below but are not easy to see. Third joint of antennæ defective; arista short plumose to middle. Face deeply concave, edge of mouth prominent. Vibrissæ at mouth, not approximated; facial ridges bare. Bucca one-fourth the eyeheight. Thoracic chætotaxy: acrostichal 0 (unless a prescutellar pair destroyed in pinning); dorsocentral 2, 3; humeral 2; posthumeral 1; presutural 1; notopleural 2; supraalar 2; intraalar 2; postalar 2; scutellum with one lateral, one large apical, one small discal.

Tibiæ all with villous hair on flexor side, less developed on front ones; middle tibiæ with three bristles on outer front side; two on outer hind, one on flexor. Wings with yellowish veins, apical cell rather widely open, not very far before the tip; third vein setulose two-thirds of the way to the crossvein; hind crossvein beyond middle of discal cell.

Length, 7 mm.

Type in Vienna museum.

78. *Parexorista inculta* Wiedemann (*Tachina inculta* Wiedemann, Auss. Zweifl., II, 1830, 33; Parexorista Brauer and Bergenstamm, 1891, 400). One female, "Brasilien," with square pink tag on pin. Another label is "Coll. Winthem." and an old brown ink label reads "inculta Wiedemann Brasilien."

Agrees with Wiedemann and is no doubt the type. The abdomen has been broken off and unskillfully attached with glue, the legs on the right side are all gone. In Aldrich and Webber's table of Zenillia it runs to *ceratomiæ* Coquillett, from the female type of which it differs but little the difference being as follows:

(a) front narrower, .29 of the headwidth (instead of .33 to .36);
(b) parafrontals and parafacials slightly narrower and not shining;
(c) second antennal joint brown, not red;
(d) the anterior reclinate frontal is lower down, about two-fifths of the distance to the lunule from the vertical;
(e) abdomen not distinctly dark banded on apical half of segments two and three;
(f) apical scutellars larger, not erect, apparently were not decussate.

In spite of these slight differences I think *inculta* would be congeneric with *ceratomiæ* on the narrowest interpretation of genera.

79. *Tricholyga vivida* Wiedemann (*Tachina vivida* Wiedemann, Auss. Zweifl. II, 1830, 312; Tricholyga Brauer and Bergenstamm, 1891, 403). One male with pink square on pin and labels "Brasilien" and "*vivida* Wd. 265, Coll. Winthem." There is also the Brauer and Bergenstamm label as type of *Tricholyga vivida* Wiedemann. Agreses with description and is no doubt the type. This, however, is not the genotype of Tricholyga. In fact it belongs to Phorocera, subgenus Parasetigena as taken by Aldrich and Webber (Proc. U. S. N. M., Vol. 63, Art. 17, 1924, 43), a close relative of *tachinomoides* and *claripennis*. It is different from any species described by us, however. In our key, on page 51, it would run to *floridensis*.

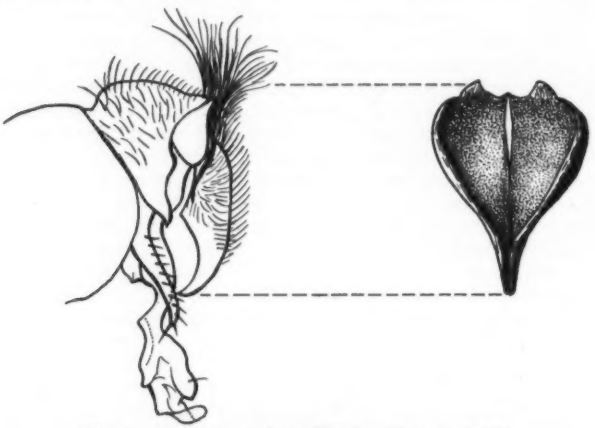


Fig. 1. *Tricholyga vivida* Wied. Male genitalia. (Drawn by C. T. Greene).

Male.—Front .31 of headwidth. General color dark gray, the scutellum reddish. The abdominal pattern in the form of rows of triangles, rather than crossbands. First and second antennal joints red, the third black, twice as long as the second; arista thickened only to middle; penultimate joint short; ocellars normal; apparently two upper reclinate frontals, but now broken off; seven or eight additional frontals extending below the level of the arista and fully to the uppermost large bristles of the facial ridges. Parafacial at narrowest fully as wide as third antennal joint. Scutellum without a discal pair of bristles; sternopleurals 3. First abdominal segment with only a minute pair of median marginals. Second and third segments with a median pair larger and some lateral; fourth segment without discals but with a few marginals. The pollen of the second, third and fourth segments ends abruptly at the side, the venter being shining except a rather faint patch on the anterior half of the second segment, coalescing with one on the first segment. Genital segments brown, the inner forceps broad at base, united into a slender, curved, sharp, hook-like, black beak. The basal

part has a ridge on each side enclosing a heart-shaped reddish portion which is depressed and covered with dense pale hairs directed backward. See figure. The hair of the ridges is also pale and directed backward; all of this hair is very fine. The outer forceps are represented only by flattened plates with a small flattened hairy process at tip. The fifth sternite is rather deeply incised, the two lobes touching each other with somewhat swollen surfaces; the fourth sternite, not incised, stands out a little. The venter has rather abundant hair but not any distinct brushes. Legs black; claws and pulvilli elongate. Wings subhyaline; fourth vein with a distinct fold at bend, ending far before the apex; third vein with six or seven hairs reaching almost half way to the crossvein. Length, 12 mm.

TWO NEW NORTH AMERICAN COLEOPTERA.
(Buprestidæ and Cerambycidæ).

By A. B. CHAMPLAIN and J. N. KNULL,*
Pennsylvania Bureau of Plant Industry.

In working over some Coleoptera, two apparently undescribed forms were found, the descriptions of which are given herewith.

Agrilus olentangyi n. sp.—Color dark bronze above and below. Head convex, front with slight median impression, antennæ serrate from the fifth joint. Prothorax wider than long, sides arcuate, constricted at base, hind angles strongly carinate, disk convex with two slight median depressions, oblique lateral depression each side well marked, surface strigose, pubescent, pubescence becoming longer at sides. Scutellum granulate, transversely carinate. Elytra wider than prothorax at base, sinuate behind humeri, dilate behind middle, apices serrately rounded, surface finely imbricate, pubescent, pubescence longer on each elytron near suture, forming a stripe the entire length Ventral surface more shining than above, prosternal lobe broadly deeply emarginate, pygidium faintly carinate, carina not projecting, first joint of hind tarsi as long as the three following joints, tarsal claws cleft, forming a stout tooth at base, similar on all feet in both sexes. Length 4.5 mm.

Male.—A median line of dense pubescence extending from prosternum to second abdominal segment, first and second segment of abdomen slightly flattened, anterior and middle tibiæ each with a short stout incurved spine on inner apical angle.

Female.—Ventral line of dense pubescence lacking, first two ventral segments normal.

*Authors' names arranged alphabetically.

According to Horn's key, † this species would come after A. *lacustris* Lec.; however, it can easily be separated by the deep broadly sinuate prosternal lobe and by the two stripes on the elytra.

Type, a male marked Texas, in the collection of Mr. C. A. Frost, to whom we are indebted for the loan of material.

Allotype female and three other female specimens, which are evidently this species, collected on vegetation along the Olentangy River, at Columbus, Ohio, on July 1 and 4, 1924, by J. N. Knull, in the collection of the authors.

Lepturges neomexicanus n. sp.—Elongate, narrow, parallel brunneus, clothed with white and piceous pubescence. Head smooth, depressed between eyes, eyes small, coarsely granulate, antennæ about twice as long as insect, annulate, ciliate beneath. Prothorax wider than long, convex, a sharp lateral spine each side, back of middle, surface clothed with white and piceous pubescence, punctures sparse, transverse row of punctures at base, scutellum rounded. Elytra wider than prothorax at base, sides nearly parallel, apices truncate, surface densely punctured, punctures becoming sparse toward apex; each elytron with pubescence as follows: A large piceous patch at base, four white stripes with piceous patches, a lateral piceous patch back of humeral angle, lateral oblique band back of middle, a long black hair arising from each patch of piceous pubescence. Ventral surface finely pubescent, punctures minute, prosternum extremely narrow between front coxal cavities, femora clavate, first joint of hind tarsi fully as long as the following joints, tarsi densely pubescent beneath. Length 6.5 mm.

Type, a male collected at Jemez Springs, New Mexico, July 17, and one male paratype collected at the same locality on July 19, in the collection of the authors.

In view of the fact that both specimens are males, we have placed this species temporarily in the genus *Lepturges*. A female may show that it should go in one of the genera with an elongate ovipositor. The authors are indebted to Mr. Chas. Schaeffer, who kindly compared the species with the type of *Lepturgoides pini* Schffr.

---

†G. H. Horn. Trans. Amer. Ent. Soc., V. 18, p. 277, 1891.

THE EFFECT OF THE VENOM OF SOME SUPPOSEDLY POISONOUS ARTHROPODS OF THE CANAL ZONE.*

W. J. Baerg,
University of Arkansas.

This is a brief account of observations on the effect of the venom of one species of centipede, two species of scorpions, and two species of tarantulas occurring in the Canal Zone. Although with the appearance of Animaux Venimeux et Venins by Marie Phisalix, there is available rather extensive literature on the various poisonous animals; the species that are discussed in this paper have, so far as I know, not been studied with regard to the effect of the poison.

The centipede is† *Scolopendra sumichrasti* Saussure. It averages 80 mm. in length, the body is blackish, legs dull yellow, and the antennae are green. The latter feature makes it resemble *S. morsitans* somewhat closely. *S. sumichrasti* was taken on Flamenco Island, located near Balboa. It is rather common there, and in the Canal Zone it is perhaps more commonly found than any other centipede. One specimen of *Scolopendra* subspinipes* Leach was taken near Colon, but owing to the fact that it was killed before I received it, the effects of its poison could not be determined.

The Centipede.

On Mice and Rats.—It might be said here that white mice are not very well suited for this sort of experimentation. They constantly behave in a peculiar manner, and it is rather difficult to decide whether a mouse is normal or not. If one would use them for a large number of tests one might perhaps become acquainted with their peculiarities, and be able to recognize

*Reseaarch Paper No. 23, Journal Series, University of Arkansas.

†Determined by Dr. R. V. Chamberlain, of Harvard University.

Acknowledgments. The studies described in this paper were made at the Barro Colorado Island Laboratory, of the Institute for Research in Tropical America, in the Canal Zone. Acknowledgment is hereby made to Mr. James Zetek, Mr. Ignacio Molino, and Mr. J. B. Shropshire for much valuable assistance. Dr. Bates, Director of the Board of Health Laboratory, generously allowed me the use of a room in the Laboratory Building, as well as all necessary equipment and experimental animals, such as guinea pigs, white mice, etc. Mr. J. A. Clark, Technician in Bacteriology, Board of Health Laboratory, kindly helped me with all the tests on experimental animals, and rendered much valuable assistance in other ways.

symptoms quite well. Rats are, on the other hand, very well fitted for these experiments. When they are normal, they sit quietly and do not try to amuse the observer, as mice do. When they are afflicted they apparently manifest their discomfort promptly and strikingly.

The centipede was placed near the left hind leg of a white mouse; it bit readily and was allowed to hold on for about two seconds. (1:20 P. M., September 4, 1924). The mouse, immediately after the bite had taken place, favored the leg very strongly in walking. After fifteen minutes it walked in a normal manner. It showed no other effects of the poison.

On the white rat (9:05 A. M., August 28, 1924), the centipede produced no symptoms whatever. The test was made in the usual way, by allowing the centipede to bite the rat on the inside of the left hind leg. The test was repeated by using another centipede on another rat, and it gave the same results.

On Man.—(1:50 P. M., September 2, 1924). The centipede was allowed to bite me, as I have described in previous tests, on the inside of the terminal joint of the small finger of the left hand. It was allowed to hold on for about two seconds. The resultant pain was quite appreciable before the fangs had been withdrawn. Fifteen minutes later the pain was noticeably less, and confined entirely to the last joint of the finger. In thirty minutes the pain was rather slight, the finger reddish. At no time was there any white area around the punctures, or any throbbing sensation. In three hours the pain had all disappeared; there was but a slight pricking sensation when I rubbed over the bitten spot.

Scorpions.*

The scorpion that is most commonly met in the Canal Zone is *Centruroides margaritatus* Gerv. The carapace, and the first four segments of the postabdomen are yellowish brown; the dorsal aspect and sides of the preabdomen, the last segment of the postabdomen, and the sting are dark with a strong bluish shade. The legs are light straw color. The largest specimen that I took is 95 mm. in length, and 12 mm. at its greatest width.

This species seems rather common on the islands in Panama Bay as well as on the adjoining mainland. Not infrequently it

*The scorpions were determined by Dr. H. E. Ewing, of the U. S. National Museum.

gets into human dwellings and reports of its stinging are rather commonly heard. The accounts that I obtained illustrate a wide range of susceptibility in man, and for this reason they will be given in some detail later in this paper.

On Mice and Rats.—Tests were made on a white rat (9:08 A. M., August 28) and on two white mice (10:46 A. M., August 30, and 1:27 P. M., September 4). Although the scorpion responded well in each case, no effects could be observed. The mice, as previously mentioned, behaved as if they were trying to show off. They did not limp, and the bitten area showed no inflammation or other effect.

On Man.—Dr. J. E. Jacob, Chemist in the Board of Health Laboratory, was stung by this species on the third finger of the left hand. The symptoms he describes somewhat as follows: A sharp pain for an hour or an hour and a half, then a numb feeling or a tingling in the left arm and left leg, extending even into the toes, finally a lameness (or difficulty to use) in the tongue. All these lasted for about twenty-four hours.

Mr. James Zetek, Resident Custodian of the Barro Colorado Laboratory, describes his experience with this scorpion as follows: the sting caused the finger to feel large, and greatly swollen; this feeling spread over the entire hand, extending to the wrist. There was a slight sensation in the forearm and all this lasted a day.

The test on myself (9:00 A. M., September 18) was rather disappointing, for no interesting symptoms followed. The scorpion stung twice and the pain was felt promptly. This was rather severe at first, the entire finger hurt and appeared reddish. After thirty minutes the pain gradually decreased, and soon disappeared entirely. All the while there was a feeling of glow or warmth in the finger, that I have not noticed in other tests.

Another scorpion, *Opisthacanthus lepturus* Pal de B., while fairly common, seems to be more or less restricted to certain localities. It has been taken on Flamenco Island and on the mainland near Punta Bruja. The largest specimen measured 70 mm. in length, and 10 mm. at its greatest width. It is of a rather uniform dull blackish color, the legs being somewhat lighter. A striking character of this species are the large pedipalps. Seeming in fact too large, they are nevertheless well controlled by appropriate muscles so that they serve very well

as weapons of defense. Nature has, in emphasizing the pedipalps, neglected the postabdomen and the sting; so that the scorpion has almost forgotten how to use the latter. It will attempt to sting only when the pedipalps cannot be used.

On Rats.—(9:15 A. M., August 28). It was with difficulty that the scorpion punctured the tender skin of the inside of the hind leg. The rat did not limp, and there was no inflammation or any other effect of the poison.

On Man.—(1:30 P. M., September 12). The scorpion after much coaxing tried seriously to sting me. All of four attempts failed, although an appreciable quantity of poison was deposited on my small finger. The poison has a dilute milky appearance and no taste.

It did not occur to me until later that the weakness of the scorpion is no serious obstacle in the making of these tests. Grasping the scorpion by the postabdomen the sting is easily driven through the skin. This I did twice, and the small drops of poison in the punctures indicated that the procedure is quite appropriate. The pain resulting from the sting was very slight and disappeared in a few minutes. The punctures were visible for several hours. There was no inflammation or other effect of the poison.

Tarantulas.*

A tarantula of rather striking appearance was sent me by Dr. J. C. Mattatol, Health Officer in Colon, who had taken it on a cork-insulated cold pipe in an abattoir at Mount Hope. Dr. Petrunkevitch found this to be a new species of Psalmopoeus. A detailed description has been published elsewhere.

On Rats and Guinea Pigs.—In the test on a white rat (10:48 A. M., August 30) the tarantula bit well and held on tenaciously. The rat showed evidence of considerable pain. About ten minutes later it moved its head forword in a rather convulsive manner, probably merely by way of getting over a fright. It did not favor the leg in walking, nor were there any other effects from the bite.

On the guinea pig the test (1:25 P. M., September 12) met with similar results. The tarantula bit well and held on for about five seconds. The guinea pig did not limp, but after twenty minutes it dragged its hind quarters. This symptom

*Determined by Dr. Alexander Petrunkevitch, Yale University.

soon disappeared, and there was no other evidence of any effect of the poison. In a second trial (September 14), using another guinea pig, there were no symptoms whatever following the bite. In this test the tarantula bit twice.

On Man.—(1:05 P. M., September 9). When the tarantula was placed in position to bite, with fangs extending forward, drops of poison were already visible at the tips of the fangs. It bit readily, but the fangs did not penetrate very well. A small amount of blood in the punctures indicated that the fangs had penetrated the skin. A good-sized drop of poison was spilled over the surface. At first the resulting pain was somewhat sharp, but in five minutes it had practically vanished. This induced me to make another trial. The fangs now penetrated deeper, and were allowed to remain for about a second. The pain was more intense than before, but again began to vanish in a few minutes. There was no stiffness, swelling, or other effect of the poison. In one hour there was no pain, the finger was just slightly sensitive.

The other tarantula, *Sericopelma communis* Cambridge, is very common in the Canal Zone. The largest specimen that I took measures 72 mm. in length, including the upper angle of the chelicerae, and 25 mm. across the cephalothorax. It is decidedly blackish in color, rather robust, and somewhat pugnacious. It is not as easily handled as, for instance, our common species, *Eurypelma californica.* The black tarantula is generally known, and quite as generally feared. A statement in the Daily Star and Herald, saying that I would pay ten cents for every live tarantula delivered at Mr. Zetek's laboratory, brought none. It required some time to learn where to find these spiders, for although every one knew them and had seen them, no one apparently could tell me where I could get them. Dry situations, under rocks, etc., are not easily found during the rainy season. The first specimen, a handsome large female, was taken in the ruins of the cathedral of Old Panama. A day later I learned that scores of tarantulas lived in burrows in the terrace between our quarters in Ancon (House 217) and Balboa Heights. Having learned also that at night the tarantulas may be seen on the outside, near their burrows, the getting of these spiders was easy. By the aid of an acetylene lamp they were readily located, and blinded or charmed by the bright light they usually sat quite still till I could place one hand in

front of the hole. Not being able to retreat into the den, the tarantulas made no attempt to escape and were easily put into a mailing tube or other container.

In view of the fact that this tarantula is so common in the Canal Zone, I believe it to be one of those that are from time to time brought to the States in shipments of bananas. The so-called "banana spider" has a reputation of being more deadly than a rattlesnake, and it was therefore with a good deal of pleasure that I began to inquire into the effects of the poison.

On Rats.—(9:00 A. M., August 28). The tarantula bit quickly twice on the inside of the left hind leg, and the reaction in the rat was immediate. It panted, held the left leg up to the body and made no attempt to walk. Fifteen minutes later it was lying on the belly; when feebly attempting to move it would go sideways, using only the front legs. The eyes were half closed. In thirty minutes the bitten area was visibly swollen and dark red or purplish in color. In an hour and fifteen minutes it began to show signs of recovery. When lifted up by the tail it opened its eyes wide. In an hour and a half it made more effort to walk, though still using only the front legs. After two hours it tried to walk on all fours, but the hind quarters were carried rather low; in three hours and forty minutes it had practically recovered. Another test with another tarantula and another rat was made with essentially the same results.

When the same tarantula was used on this rat again on the next day, the rat showed no significant symptoms. By trying another tarantula on the third day it was learned that these spiders apparently need more than twenty-four hours to accumulate an effective dose of the poison. This third test produced symptoms nearly as severe as the first. In fact, the rat required considerably longer time to regain the full use of her hind legs.

Making the test for the fourth time (September 5) the rat, although very lame at first, soon recovered. In about two hours it seemed to be entirely normal. It appears therefore that immunity against the venom of this tarantula may be developed with three or four doses of the poison.

One test was made on a large rabbit (Belgian hare). To the bite of the tarantula the rabbit responded with a loud wailing squeal. No other effects of the bite were observed.

Guinea Pigs.—These animals are not well suited to poison tests, for they apparently do not manifest clearly any state of illness; they are either alive or dead. When the guinea pig had been bitten (8:30 A. M., August 29) it seemed rather nervous, licked the injured leg very frequently, alternating this with washing its face. It was very active, walking on all four legs. Its restlessness was the only indication of pain. For thirty minutes it behaved in this manner; four minutes later it was dying.

In another test the guinea pig died twenty-three minutes after the bite took place. In a third trial the guinea pig recovered. Recovery was apparently due to the fact that the tarantula struck near a large blood vessel and the bite resulted in considerable bleeding. This guinea pig showed no sign of illness, excepting that it did favor the bitten leg slightly during the first half hour after the bite took place.

On Man.—(8:44 A. M., August 29). In this test some precautions were taken so that I would get a relatively small dose of the poison. Only one fang punctured the skin and this was allowed to remain for about one and a half seconds. Rather severe pain developed at once. In a few minutes the finger felt numb and the pain was so strong that I applied dilute ammonia, about ten minutes after the bite had taken place. At this time the small finger was perceptibly swollen, rather red, and stiff. In fifteen minutes there was a strong throbbing and the swelling had increased considerably. Some more ammonia was applied. In thirty minutes the finger was so stiff that it could scarcely be bent, the skin was very red and glowing, the pain seemed somewhat less. In an hour, the sharp pain had largely subsided, there was a strong tingling sensation, and the stiffness and lame feeling extended to the third finger. The swelling gradually spread over most of the hand. It did not go beyond the wrist.

Two hours after the bite took place (believing that the effects would be no more than local), I decided to try hot water as a remedy for the pain. After keeping the hand in comfortably hot water for thirty minutes the pain was practically gone, most of the swelling had likewise disappeared, and the stiffness was somewhat lessened. A peculiar sensitiveness and stinging sensation, felt when gently rubbing the skin, remained for some time. All other pain disappeared within six hours

following the bite. A lameness in the joints of the small finger persisted for nearly a week.

Sericopelma communis may, in view of these observations, be regarded as poisonous. The effect of its venom is likely to be somewhat painful, though perhaps in most cases not dangerous.

All the preceding tests with the black tarantula were made with the female of the species. The males are curiously temperamental. When touched with a pencil or bit of stick they will jump at it, bite, and pour poison over it very generously; however, if one tries to induce them to bite a rat on the inside of the hind leg, the males take on an extremely indifferent attitude. Only one out of six or more trials succeeded. While the results are not conclusive, indications are that the bite of the males has approximately the same effect as that of the females.

The Poison Apparatus.

The study of the structure of the poison apparatus of the various arthropods is offered as a brief supplement, and makes no pretense at completeness.

The fangs of the centipede, *Scolopendra sumichrasti*, represent, as is well known, the first pair of legs. The gland, whitish and rather slender, is 3.35 mm. in length and .5 mm. at its greatest width. The gland opens through a slit-like opening, dorsally near the tip of the fang.

Poison apparatus of the scorpions show that in *Opisthacanthus lepturus* a marked reduction in the gland as well as in the accompanying musculature has gone together with the striking development of the pedipalps. The gland of this species is 4 mm. in length and 1.25 mm. at its greatest width; that of *Centruroides margaritatus* is 5 mm. in length and 1.7 mm. at its greatest width. The glands in both species empty through small narrow openings laterally near the tip of the spine.

The poison apparatus of *Sericopelma communis*, female and male, and *Psalmopoeus pulcher*, male, seems quite comparable to that of our native species previously figured. The poison gland of *P. pulcher* measures 8 mm. in length and 2 mm. at its greatest width. The poison gland of the female Serico pelma is decidedly more plump than that of the male. The former measures 9 mm. in length, and 2 mm. at its greatest width. The latter is of the same length, but only 1.5 mm. in width.

NOTES ON THE OVIPOSITION OF SOME KANSAS CICADAS.

By R. H. Beamer,
University of Kansas.

In spite of the fact that cicadas have been known and written about since medieval times very little is known of their life histories. This lack is doubtless due in a large measure to their habit of passing the entire nymphal stage below the surface of the ground and because in most cases this period is supposed to last from several to many years. Members of some of the Kansas species emerge in large numbers every year, a constant challenge to one so inclined, to solve the secret of their life cycle. The present paper is a presentation of observations on the oviposition, eggs, and egg parasites of some of our commonest Kansas forms. Observations have been made on seven species and one variety, namely, *Tibicen aurifera* (Say), *T. auletes* (Germar), *T. dorsata* (Say), *T. resh* (Hald.), *T. lyricen* (Degeer), *T. marginalis* (Walk.), *T. pruinosa* (Say), and *T. pruinosa* var. *fulva* Beamer.

The mechanics of oviposition are the same, so far as observed, with each of the above species and are as follows: The female stands with head toward the upper or outer end of the stem or limb. Raising the abdomen away from the support she curls the tip under until the ovipositor, springing clear of the two sheathing valves, strikes the material to be pierced at right angles. The spear-shaped ovipositor is rotated from left to right and back, cutting across the grain until it has pierced well into the limb, then gradually changes its angle of cutting until the main part of the excavation is longitudinal to the limb. The excavation completed, the eggs are arranged in perfect order from the bottom of the slit out, the anterior end of each egg nearest the opening. They are usually in two rows.

Having filled the cavity, *Tibicen marginalis* (Walk.) moves slightly up and just a little to the side to begin her new nest, leaving her old one all torn and gaping open, taking seemingly no care whatever to protect the eggs she has just deposited. When this second nest is finished she moves directly up the limb, one ovipositor length, to begin another pair of nests,

proceeding in this manner for as much as six or eight inches along the limb. Often the scars are arranged in a wavy line instead of a straight one. *Tibicen resh* (Hald.), *T. dorsata* (Say), *T. auletes* (Germar), *T. pruinosa* (Say), and its variety *fulva* Beamer all take correspondingly little care of their nests. *Tibicen aurifera* (Say) and *T. lyricen* (Degeer), however, secrete a glue-like substance in the opening of the cavity and pat down in place the ragged edges of the torn tissue with the two heavy sheathes of the ovipositor, leaving little evidence of their work.

All of the species which have been observed oviposit in trees or shrubs, except *Tibicen aurifera* (Say), which uses the hollow stems of grass. Some of the species prefer small green twigs; others the corky bark of larger limbs. It is surprising how frequently they choose the hardest, dryest, dead twigs in which to oviposit. Several females of *Tibicen resh* (Hald.) were shot while ovipositing in Black Jack oak (*Quercus marilandica* Muench). It was necessary to climb the tree and break off the limb to obtain the specimens, because the ovipositor was inserted full length into the hard, well seasoned wood of a dead twig. *Tibicen auletes* (Germar) is another lover of dry dead twigs, preferring oak and willow. There is no regularity in the positions of the nests of this species as there is in some of the others. They are just scattered around on the under side of the limbs at random, small twigs not larger than three-quarters of an inch being preferred. *Tibicen marginalis* (Walk.) on the other hand, seems to prefer the soft green limbs of birch, willow, and maple, or the spongy bark of cottonwood, or the heavier bark of the trunks of willow. The kind of wood in which the nest is placed has a great deal to do with the external appearance of the wound. Birch is badly torn by the ovipositor, while the soft bark of the cottonwood barely shows the puncture. *Tibicen pruinosa* (Say) and the variety *fulva* Beamer appear most indifferent to kind or quality of host, having been found ovipositing in ash, walnut, elm, maple, and sumac in both green and dead tissue. *Tibicen dorsata* (Say), our most common Kansas species, has been observed ovipositing in willow and American Elm. It undoubtedly has many more hosts, but, owing to its wary nature, is difficult to observe. Unlike most of the Kansas species which are commonly found in trees, it seems to prefer scattered shrubs, weeds and even meadow

grasses. Many nests with ragged and torn edges have been found in the dry stems of dead dog-wood (*Cornus Baileyi*) which are thought to have been made by this species, but as yet we have no definite proof.

Tibicen lyricen (Degeer) has been observed ovipositing in the small dead twigs of oak and persimmon and the green limbs of peach and there is no doubt that it has many more hosts. A very peculiar as well as interesting habit of this species is that from one opening in the bark there may be one, two, or three nests of eggs. The nests may all be in the same general plane, radiating from a common center, or one may be below the others. From six to twelve eggs are found in a nest, usually eight.

Tibicen aurifera (Say) oviposits in Panic grass (*Panicum virgatum*) as a rule, but one series of nests was found in Wood grass (*Sorghastrum nutans*). The punctures are placed with meticulous care in a perpendicular line, each one just about the length of the ovipositor above the last. The eggs are placed in two rows, from twelve to twenty-two eggs in a nest, and from one to seventeen punctures in a stem. The nests are always separated by a little torn tissue.

The eggs of the different species of cicadas vary in appearance only as to size. Those of *Tibicen auletes* (Germar) measure about 2.75 mm. in length and 0.5 mm. in width. The chorion is smooth, shining and transparent, revealing the internal structure quite distinctly. The eggs are white in color and somewhat spindle-shaped, a little more sharply pointed at one end than at the other.

While making observations on the oviposition of *Tibicen aurifera* (Say), the writer's attention was attracted by a small metallic green wasp running up and down the stem over the egg punctures and even upon the body and wings of the cicada herself. She was not found ovipositing, but it seemed probable that she might be parasitic on cicada eggs. Hence a number of the grass stems close at hand were taken to the laboratory for further investigation. An examination a few weeks later showed about 50% of the egg nests to be occupied by a small white grub which grew as the eggs disappeared until it neatly filled the nest. Where the material was kept at room temperature in the laboratory the adult emerged in mid-winter—the same metallic green hymenopteran which had been observed

in the field. From material which was kept in natural conditions, however, the adults did not emerge until the next summer about the time *T. aurifera* (Say) normally oviposits. Mr. A. B. Gahan, of the U. S. National Museum, has identified this parasite as a new species of the Chalcid genus *Syntomaspis*.

This interesting discovery led to the examination of the egg masses of other species of cicadas. Twigs bearing the nests of *Tibicen marginalis* (Walk.) yielded a number of specimens of another parasite. Mr. S. A. Rohwer, also of the U. S. National Museum, reports these to be a new species of the Braconid genus *Heterospilus*.

These discoveries are of particular interest and seem quite unusual, as indicated by the following excerpts from a letter from Mr. S. A. Rohwer:

"The species of the genus *Syntomaspis* are usually parasitic on gall insects and it seems to us very likely that there has been some error in your rearings. It would be extremely unusual for the species of this genus to be parasitic on the eggs of Cicadas." Again, "All of the species of the genus Heterospilus whose habits we know anything about are parasitic on wood borers or insects feeding within the stalks of grasses. While it is not impossible that they might be parasitic on Cicada eggs, it seems highly improbable." And further, "I think you should be very careful in recording either of these parasites as coming from the eggs of Cicadas unless your records show definitely that they emerged from such eggs. I have a suspicion that you have some of those small Cynipid galls which split the bark and have the appearance of insect eggs."

Since the writer feels there can be no doubt as to the accuracy of the observations, the above comments only add interest to the discovery.

MODIFICATION AND DEVELOPMENT OF THE ARACHNID PALPAL CLAW, WITH ESPECIAL REFERENCE TO SPIDERS.*†

WILLIAM MORTON BARROWS,
Ohio State University.

INTRODUCTION.

Among the many devices of animals which aid in the transfer of sperm cells from the male to the female, three are so out of the ordinary that they have attracted a good deal of attention and are usually mentioned together. These are the hectocotylized arms of male cephalopods, the penis on the second segment of the abdomen of male dragon flies, and the highly developed palpal organs of male spiders. In the three groups the process of sperm transfer is more or less analogous. Since the animals are not related, the processes are to be considered merely as parallel developments.

Several careful investigators have studied the copulatory process in spiders and have attempted to account for the origin of the process, and for the development of the peculiar tubular organ on the palp of the male. The details of copulation are now well understood. They may be summarized briefly as follows: At some time previous to the last molt, there develops on the distal segment of each palpus of the male a complex organ, the essential feature of which is an elongated infolded sac, which is capable of sucking up, holding, and discharging semen. Before copulation the mature male discharges a drop of semen from the genital aperture in the abdomen on to a web, either especially constructed, or part of the normal web of the species. This drop of semen is then sucked up into the two palpal organs. The male is now ready to copulate with the female. Copulation differs considerably in different species, but the process is in the main merely the insertion of the tip of the palpal organ into the spermathecae of the female, and the

*Publication of this paper has been made possible by a grant from the MacMillan Fund by the Trustees of the Research Fund of the Ohio Academy of Science.

†Contribution No. 86 from the Department of Zoology and Entomology of Ohio State University.

immediate discharge of the semen into these organs. This discharge is usually accompanied by a considerable swelling of the blood spaces (haematodocha) of the palpal organ, which would seem to indicate that the discharge of the semen may be accomplished by an increase of the blood pressure surrounding the tube. (Montgomery, '03).

Aside from a considerable knowledge of the use of the palpal organ, which has been beautifully summarized by Montgomery ('03), and a preliminary comparative study from the standpoint of taxonomy of the palpal organs of several species of spiders by Nelson, '09, and Comstock, '10, our information concerning this organ is very meagre.

Spiders of the Mesozoic possessed, in many cases, complicated palpal organs, but those of the Palaeozoic, where one would expect to find the beginnings of this organ, are too few and too poorly preserved to offer any clue to its origin. (Petrunkevitch '13, p. 23).

Statement of the Problem.

Since the origin of the palpal organ, and consequently its homologies, cannot be determined at present from palaeontological evidence, the main hope for solution must lie either in the study of the homologous organs of other arachnids, or in the study of the embryonic or post-embryonic development of the organs itself. In this paper we will use both methods of attack.

The incentive to attack this problem arose in a rather peculiar manner. During a discussion of the habits of spiders, Dr. R. C. Osburn asked me what structure could possibly have given rise to such a curious organ.* Without looking up the literature on the subject, I replied that so far as I could see, the structure must be a metamorphosed palpal claw, because the adult male palp usually lacks a terminal claw while the female palp usually possesses one. It now seems likely, that if my reply had not been so rash, a series of fortunate accidents, leading to the solution of this problem, would not have followed. In attempting to substantiate this view-point the palpal claws of some of the more primitive spiders, among them Brachy-

*It is a distinct pleasure to acknowledge that I have received much valuable help and encouragement from Dr. R. C. Osburn during the preparation of this research, as well as the original suggestions which led me to attempt it.

bothrium, Ariadne, and Dysdera, were examined. In Dysdera the female palpal claw is hollow and appears to be lined with a separate layer of chitin, that is, it appears to be similar to the palpal organ of the male. In spite of the fact that this initial observation may have been incorrect, it led to a careful study of the palps of other arachnids and a study of the development of the palpal organ in three species of spiders, which has filled several gaps in our knowledge, and seems to have cleared up some of the mystery surrounding this organ.

In this paper I will divide the material for a more logical presentation into two main parts, (a) a comparative study of the arachnid palp, and (b) a study of the development of the palpal organ of the male spiders belonging to the species Steatoda borealis (Hentz), Lycosa helluo Walckenaer, and Phidippus audax (Hentz).

Part I. Comparative Anatomy.

The literature dealing with comparative studies of the palps and other appendages of arachnids is very meagre. In most of the earlier researches the palps are considered only from the standpoint of taxonomy and in most cases the authors have followed established customs in naming the parts, or have depended on gross appearances in naming segments, instead of making careful dissections and comparisons. It will be necessary as a result of this lack of uniformity to consider each group by itself in order to arrive finally at a correct estimate of homologies. One is further embarrassed in an inquiry of this kind by the entire lack of agreement as to the phylogeny and mutual relationships of the Arachnids. The group is now in such a chaotic state that it will be unnecessary to follow any particular scheme in our review of the orders.

One important question, namely, the relationship of terminal segments of appendages to claws, will make it advisable to include in this discussion references to the appendages of the Xiphosura and some of the extinct arachnids, and to discuss the claws of all the appendages in order to be sure that the homologies are safely interpreted, and, if possible, to determine whether a claw is a segment or not.

Order Xiphosura.

The palps of Limulus, both in the male and female consist of five segments and a claw. The basal segment, the coxapodite, with its gnathobase is almost typically arachnid in its shape and function. The following joints, trochanter, femur, tibia, metatarsus, and claw (movable finger), the two latter forming a chela, call for little comment except that the sexual dimorphism is striking. (Fig. 1 and 2). Undoubtedly the modified chela is useful to the male in the mating period. It is said that the male clings to the abdomen of the female by means of the

modified chela. (Montgomery '03). Montgomery states that "in Limulus the distal end of each of these swollen joints opens to the exterior by a minute aperture, which is readily determined on dissection" ('03 p. 136–137). I cannot convince myself that these "apertures" are real openings with any real function. They appear to be made either by the wearing of the end of the joint or by a folding of the chitin. There certainly is no gland or invagination comparable to that of the poison gland of the spider connected with either aperture.

Figures 1 and 2 show the female and male palps: Fig. 3 represents the right chelicera while Fig. 4 represents the terminal segments of the right female palp. The names given to the segments are not intended to indicate homologies between these segments and the segments of either arachnids or crustacea, but are intended to conform at least partially to the scheme which is advocated later in this paper. The muscles of the claw and penultimate segment of the palp (Fig. 4) are clearly much more like those of the crayfish than like those of any arachnid. It will be noted that the flexor unguium muscle does not extend beyond the confines of the penultimate segment as it does in the scorpion (Fig. 6). The muscles of the male palp are similar to those of the female except that the flexor unguium of the penultimate segment is much larger.

ORDER SCORPIONIDA.

The pedipalp of the scorpion (Fig. 5) consists of six joints which have been variously named by different authors. After having compared these segments with the corresponding segments of the spider's palp, (Fig. 12), and after having studied the attachments of the muscles in each and compared them with the muscles of the first legs of spiders and scorpions, it seems best to use the terms coxa, trochanter, femur, tibia, metatarsus, and claw in describing the segments of the palps. Figure 6 shows the muscles which flex the claw against the immovable finger of the hand. It is evident that the muscle with the very long tendon corresponds to the flexor unguium of the spider's palp and foot, which has its origin in the latter case, in the tibia (Figs. 12, 13, 14). The extensor unguium, which in most arachnids attaches to the upper side of the claw, has here (scorpion) shifted its insertion to the lower side of the claw, and attaches in many separate bundles around the tendon of the flexor unguium (Fig. 6a). Both of these muscles close the chela, but the flexor unguium when contracting, also bends the hand inward toward the mouth. One must suppose that the chela is opened by an increase of blood pressure in the hand as no muscles having an extensor function are present. The palpal claw shows no evidence of containing an invaginated organ homologous to that of the pseudoscorpion, spider, or solpugid claw.

The terminology applied to the palp will do very well for the leg of the scorpion (Fig. 8). Here the segments should be named, coxa, trochanter, femur, tibia, metatarsus, tarsus 1, tarsus 2, and claw. No patella comparable to that of the spider is present. The names used here do not agree with those given by Kræpelin, Simon, or Pocock (Cambridge Natural History, Vol. IV, p. 303-304), but have the advan-

tage of being applicable to the segments of the legs of spiders and other arachnids, if the muscles and tendons of the claws are taken into consideration. The claws found on the legs of scorpions show an interesting condition. They are heavy and separately inserted on the soft basal portion of the claw segment. In other words, the terminal segment of the leg has not split to the base, but remains as a *definite short segment.* In this connection it is interesting to note that the feet of Silurian scorpions show only a short single claw like those of the trilobites (Petrunkevitch '13, p. 31) (Walcott '18, p. 43, and 159). The later Palæozoic scorpions, however, have divided claws. This feature is particularly interesting because it shows the development of the double or split claw in one order from the ancestral single clawed condition which still persists in modern Crustacea, Xiphosura, and possibly in some of the Opiliones.

The chelicera (Fig. 7) shows many similarities to the same organ of Limulus. In some scorpions, however, the claw of the chelicera is split (unguiform); in others, part of the claw closes on each side of the immovable finger, indicating a partial splitting or twisting of the claw.

ORDER RICINULEI.

In this very interesting order which has been carefully studied and monographed by Hansen and Sörensen ('04), the pedipalp is quite different from the pedipalps found in other orders, both in the number of segments, and in their peculiar shape and relative motions. This peculiarity has, I believe, led Hansen and Sörensen into an error in naming the segments of the palps. Figure 9 is a line copy of Figure 10 Plate VII, of Hansen and Sörensen's monograph. It represents the pedipalp of Cryptostemma crassipalpe as seen from the front. In discussing the pedipalps these authors state on pages 124 and 125 that "In Ricinulei the basal joints of these appendages are united to each other, as in the Uropygi, but to a much greater extent than in these latter, whilst in all other Arachnida, apart from Acari, they are free."

"The palpi present a structure which is quite unique amongst Arachnida. They consist of two trochanterial parts, one femoral, one tibial, and one extremely small tarsal part. The first trochanterial part of the palpus is short, almost pyriform and admits of no movement relatively to the mandible except upwards-outwards and downwards-inwards, but this movement is not performed in a straight, but in a rather arched line. The second trochanterial part is somewhat compressed, the posterior (lower) portion being expanded, and it can be moved relatively to the first trochanterial part in a somewhat slanting direction forwards and backwards; when it is extended backwards as far as possible the corner of the posterior expansion touches this trochanterial part. When viewed from the outside, the transverse line of contact between the second trochanterial and the femoral parts is quite straight, and the connecting membranes is not visible from the outside; the relative movement between these two parts consists in a rotating movement of the femoral part around its own longitudinal axis to the extent of nearly 180 degrees—a feature of which we know no

other example in Arachnida or indeed Condylopoda of any kind. The femoral part is always stout, though not equally so in all species; it is always stouter in adult specimens than in young animals. In shape it is but slightly compressed or not at all so and the greater or smaller part of its distal portion presents a longitudinal excavation of the ventral surface. The tibial part of the palpus is more than half as long again as the femoral part, and at the same time much less stout; it is cylindrical, but of somewhat different shape in different specimens; it can be —and is in reality often found—bent inwards along and close to the ventral surface of the femoral part. On its ventral surface, close to its distal extremity, it carries a small process of which the dorsal margin, at least sometimes, is distinctly serrate, and against that the tarsal part can be adduced, so that together they form a small chela. The tarsal part is always very small, but at the same time always considerably larger than the process on the tibial part; like the tibial part it is capable of movement only in the plane of the limb; that is to say, of flexion and extension."

"In so far as the palpus in Ricinulei terminates in a small chela it may be said to present some similarity to the same appendage in Thelyphonoidea. But otherwise it is, as we have already pointed out, very different from what appears in the other Arachnida, chiefly on account of the remarkable torsion between second trochanterial and the femoral parts. By this means the animal is enabled to direct the end of the palpus both forwards and backwards, as we have shown in Figure 10, where we have represented one of the two plapi in each of the opposite positions. On account of the movability in the two first articulations the palpus is able to reach the mouth with its end, in either of these positions. As regards the number of joints in the palpi, Ricinulei do not differ from the other orders of Arachnida except Acari; the number being five in them all; it would be quite natural to suppose as indeed has been done, that these five joints represent the same sequence of homological equivalents in all cases. But this would be an error, as may perhaps be proved in the clearest manner by comparing the palpus in Ricinulei with that in Araneæ. In both orders the basal joint of the palpus is trochanterial, and the last tarsal, but whilst the second part in Ricinulei is trochanterial like the first and the third is femoral, the second joint in the palpus of Araneæ is femoral, and the third a patellar part."

The above discussion has been quoted in full to show that the usual method of naming segments is on their external appearance only. Hansen and Sörensen call the last segment tarsus, while it is quite obviously a claw. If the conditions in the Ricinulei are at all like those in the Scorpionida we would expect the segment next the terminal to be the metatarsus and the next proximal segment—c in their figure—the tibia. This would necessitate calling the short segment, b, the femur and the next trochanter. I know of no law or principle which would in any way prevent the femur from developing as a short, wide segment except the general observation that it *usually* does not develop in that way. As a matter of fact only a dissection of the muscles will demon-

strate which interpretation is correct but the external curves of the three terminal segments, c, d, and e which indicate muscle attachments, and their planes of movement, indicate rather clearly that they should be named as they are in the pseudoscorpion and scorpion (Fig. 5 and Fig. 40).

According to Hansen and Sörensen the legs of the Ricinulei are peculiar in that they have both patella and tibia; the first and second pairs have one trochanter, while the second and third each have two trochanters. The first pair of legs have only one tarsal joint; the third three, while the second and fourth have five tarsal segments. Each tarsus ends in two simple claws. On the two posterior tarsi they are easily retracted into a groove. The male is peculiar in having the metatarsus and the first and second segments of the tarsus of the third leg modified into what has every appearance of being a copulatory organ of some kind, possibly one which is used to hold a spermatophore. Obviously the organ is not homologous, in any way, to the palpal organs of male spiders, but shows another case of a similar specialization of male individuals in species in which the females are not so modified.

ORDER PALPIGRADI.

These widely distributed archaic arachnids belonging to the genus Kœnenia show in the palps and in many other parts of the body the simplest conditions known in the whole arachnid group.

The pedipalp is long, leglike, and without the usual gnathobase. According to Wheeler '00 the palp consists of the following segments; coxa, trochanter, femur, tibia (fused with patella), metatarsus (two joints), tarsus (three joints). It ends in two claws and a curved pseudonychium. Part of Wheeler's statement concerning the pedipalps appears to be quoted from Hansen and Sörensen :97, who apparently furnished the names for the segments. The use of the pedipalps, the second pair of limbs is explained by Wheeler briefly as follows (p. 841): "Although the second to sixth pairs of limbs are all used in running, the very long third pair are usually held aloft like antennæ when the animal is not disturbed and is moving about slowly."

It is rather curious that an animal so evidently primitive as is Kœnenia, with the pedipalps functioning as legs, should possess on this organ double claws, which are so far removed from the ancestral single clawed condition. It is to be explained, I believe, either on the same basis that other anomalies are accounted for, namely, that some arachnids are primitive in some parts and specialized in others, while other forms may show the conditions reversed or differently combined, or that the single claw of some arachnids is really an advanced condition beyond that of the double clawed condition.

The cheliceræ of the Palpigradi are chelate. "The first pair of legs, using the term in the restricted sense just indicated, are the longest of the appendages, and resemble the corresponding appendages of the whip-scorpions on having the tarsi broken up into several segments, each of these legs consisting of twelve segments." (Comstock '10, p. 15). Each leg is furnished with a pair of claws.

ORDER OPILIONES.

The members of this order are rather uniform in having a pediform pedipalp consisting of six segments. The claw is usually present and may be quite large or in some families apparently lacking altogether. The basal segment of the pedipalp forms a weak gnathobase. The six segments of the palp are here named in order: coxa, trochanter, femur, patella, tibia, metatarsus and claw. Aside from slight modifications in length and thickness of the segments or a few spurs or heavy spines one meets with little specialization in the whole group. The claw is somewhat variable. The commonest type is a small curved single claw, with or without a few simple teeth. In the Laniatores the claw is very large and pointed. It "can be clapped against the tarsal part and this serves to catch the prey." (Hansen and Sörensen '04, page 25).

Owing to the difficulties of dissecting or clearing the palps of the common phalangids it became necessary, in order to identify the muscles and tendons, to use a specimen of Scotolemon flavescens from the Mammoth Cave of Kentucky. Figure 10 shows the tip of the left palp drawn much enlarged. The claw is large and heavy and is obviously operated by the usual tendons. The extensor unguium muscle originates on the dorsal wall of the penultimate segment. This muscle shows no striation and may for this reason be regarded as non-functional. The flexor unguium muscle extends from the claw through the penultimate segment—the metatarsus—into the tibia where a large part of it attaches. The penultimate segment counting the claw as the ultimate, for the reasons given above must be called the metatarsus, not the tarsus as it is usually called in works on the Opiliones. The jointed hairs of the palp add to its picturesqueness, and are very likely useful in capturing prey. These hairs with their bases are larger in most cases than the terminal claw. They bend freely in one direction but are prevented from bending beyond the perpendicular by a projecting back. They are not equipped with muscles, a fact which leads me to believe that since the hairs are large and jointed at the base, it is not the movable joint of the claw or other segment which causes the development and attachment of muscles. In other words the muscles are not structures which develop to meet the needs of a joint but are structures whose presence is as important and as much a part of the appendage as are the segments themselves. This view is borne out still further by the muscles which attach to the immovable claw of the whip-scorpion, (Fig. 34). Without this concept of the fundamental individuality of the muscles it would not be possible or advisable to carry out the scheme of homologies advocated in this paper.

The palpal claws of specimens of Liobunum vittatum which have been killed in alcohol show a peculiar condition which, although not thoroughly verified, brings out an interesting comparison with the palpal claws of spiders. In a vial containing several males and several females, the palpal claws of the males were drawn down, i. e., were flexed while those of the females were extended or drawn up dorsally. It seems likely that this indicates that while the harvestmen do not have the claws of the palps sexually specialized the muscles which

operate these claws may nevertheless be different in strength in the two sexes as they are in mature spiders.

The legs of the Opiliones may be long or short. They are rather uniform in the number of segments present except for the tarsus which may consist of several true segments, or several false or partial segments, or a combination of the two.

The claws of the feet are peculiar in that they may be single or double. "In Cyphophthalmi all legs are furnished with one large and very movable claw. In all Palpatures hitherto described the legs carry one claw; in Laniatores the first two pairs of legs have one claw, whilst the two posterior pairs have two, excepting the family Trænonychoidæ, where the two posterior pairs of legs have only one claw, which however differs in shape from those on the two anterior pairs." (Hansen and Sörensen '04, p. 30).

In the second leg of Scotolemon flavescens the terminal claw is much like the single claws of other arachnids. The posterior pair of feet of this specimen terminate in double claws. In each leg the claw muscles should take their origin in the metatarsus and tibia. Naming the segments in such a way that they will fall into our general scheme, we find the following segments: coxa, trochanter, femur, patella, tibia, metatarsus, eight tarsal joints, the proximal much longer than the others, and a terminal claw.

The cheliceræ of Scotolemon are chelate like those of the scorpion and appear to have the same muscles, though their small size makes this difficult to determine.

ORDER ARANEÆ.

A very considerable amount of work, particularly with reference to taxonomy, has been done on the palpal organs of spiders. We cannot do better, perhaps, than to quote a summary of this work as it is given by Comstock ('10, pages 161 and 163).

"Notwithstanding the general recognition of the value of these organs for taxonomic purposes our knowledge of their structure is very inadequate. Several important contributions to this subject have been published, and are well known, notably those of Westring ('61), Menge ('66), Bertkau ('75 and '78), Wagner ('87), Van Hasselt ('89), and Chamberlin ('04 and '08). Still we find, even in the more recent publications, figures of palpi given with almost no effort to identify their parts; and even when some of the parts are named we find different terms applied to homologous parts in the descriptions of different genera."

"A study of the palpus of Filistata gives a clue to the probable course of evolution of the genital bulb. It is evident that the bulb is a specialization of the tip of the tarsus, and its most striking feature is the presence within it of the coiled receptaculum seminis. Regarding the origin of the receptaculum seminis, the fact that it is furnished with a transversely striated intima, like the intima of a trachea, indicates that it is merely an invagination of the body wall. In its primitive form, it was probably a cuplike depression in the tip of the tarsus."

Without paying too much attention to the terminology which has grown up around the palpal organs of spiders it will be advisable for us to begin at the beginning and examine the structure of the palps of several male and female spiders in order to have a satisfactory foundation upon which to build. The three species selected for study show separate conditions which may be considered to furnish critical evidence bearing not only on the origin of the palpal organ, but upon the homologies of the parts of this organ.

Eurypelma californica Ausser.

A male and female "tarantula" belonging to the species Eurypelma californica Ausser from Utah* (See Smith '08, p. 223) furnished palps large enough to dissect easily under the binocular microscope. The muscles of the palps were studied and compared with those of the legs, and named as far as possible according to Petrunkevitch ('09).

The pedipalps of this species are long and leglike, and consist of six segments. The terminal segment carries a single claw which bears no teeth. (Figs. 12, 13). The segments, if named according to the usual nomenclature, consist of coxa, trochanter, femur, patella, tibia, tarsus, and claw. Comparing the segments of the palp (Fig. 12) with those of the leg of the same species (Fig. 14) it will be seen that it is not the metatarsus which is lacking in the palp, but the tarsus. Hence a revision of the names of the segments of the palp is necessary. They should be named, coxa, trochanter, femur, patella, tibia, ***metatarsus***, and claw. The claw of the female palp (Fig. 12) is flexed by a long tendon and muscles which takes its origin from the dorsal surface of the tibia (Fig. 12, fl. u.). The claw is extended by a similar tendon and muscle (ex. u.) which originates in the dorsal proximal part of the metatarsus. Female specimens killed in alcohol usually have the claw very strongly retracted into a groove which occurs in the tip of the metatarsus. This retraction appears to be due to the fact that the extensor unguium is much more powerful than the flexor.

Turning to the palp of the male, (Fig. 13), we find a very similar appendage to that of the female, except that the proportions of the parts are different. The basal segments of the male palpus are quite similar to those of the female. The tibia of the male is much longer and more robust, while the metatarsus is much shorter. A dissection of these joints of the male shows clearly (Fig. 13) that this difference is correlated with a difference in the size of the extensor and flexor muscles of the claws; the extensor unguium here being about the same size as the extensor unguium of the female, while the flexor has increased to a very considerable size. The tendons of both muscles are ***shorter*** than they are in the female and ***both are joined to the base of the palpal organ!*** The latter is simple, showing no teeth or accessory parts, a fact which will be commented upon below. Figure 13 shows quite definitely that the shortness of the metatarsal segment is in some way correlated with the enlargement of the flexor muscle, also with the considerable

* Presented to me by my friend Mr. R. J. Sim of Jefferson, Ohio.

flexion of this segment and the palpal organ. The latter is evidently the palpal claw and is much larger than the claw of the female. The palpal organ is terminal as in all primitive spiders and shows a considerable torsion around its longitudinal axis. This twisting has divided the organ into three parts, a circumstance which apparently led Comstock to assume basal, middle and apical divisions as the fundamentally differentiated parts of the palpal organ (Comstock '12, p. 109). One is led almost irresistably to make the assumption that the increased size of the flexor unguium and the strong flexion of the end of the palp are in some way correlated with the process of discharging sperm from the bulb or at least an essential part of the mechanism for such discharge.

The legs of all spiders consist of seven segments; the terminal one bearing a double claw, which may or may not be equipped with a series of teeth. Quite commonly the terminal claws bear between and below them a third claw. The latter may be united solidly with the former or may be connected with them by a soft membrane. In Eurypelma the feet bear two long curved claws which are shown here, together with the associated chitinous thickenings, in Figure 15. Beginning with the claws it will be noted that each claw is slightly movable because it is inserted in a thin flexible membrane (m). Proximal to the claws are right and left thickened areas (a) which seem to be homologous with the lateral plates of the feet or other arachnids. The specimen from which this drawing was made had been boiled for a short time in K O H so that the chitinous thickenings are somewhat more definite than they are in the normal unboiled foot. Below the lateral thickenings is a heavy piece of chitin (t. pl.) to which the tendon flexor unguium attaches. This may be called the tendon plate. A projection of this plate probably forms the third or unpaired claw which is found in some other spiders (Fig. 22). Proximally to the lateral thickenings and tendon plates are two sets of elongated thickenings (b, c) not easily separated, which surround the opening into the central part of the foot. These are rod-like thickened pieces, the right and left pairs of which touch at their dorsal and ventral ends and are much bowed apart in the center. They very likely represent the base of the single segment from which this split foot has been developed. The foot is attached to the tarsal segment by means of a thin joining membrane (j. m.) which forms part of each tendon and joins the sides of the foot along the outside anterior edge of the rodlike thickenings (c). The single claw of the female palp shows traces of thickenings similar to those which have been described for the foot, although they are not so clearly defined

The chelicerae of the spiders are much like those of the other arachnids, which show only two cheliceral segments. One chelicera of Eurypelma is shown in Figure 16.

Brachybothrium pacificum Simon.

The Folding-door Spider, Brachybothrium pacificum Simon, shows a set of structures very similar in the main to those of Eurypelma californica, yet different enough, in certain respects to make a comparison quite desirable. The palps of these spiders are shown in Figures 17

and 18. There is little in the shape of the palp as a whole that requires discussion. The claws themselves are quite different from those of Eurypelma. The female claw, when much enlarged, shows two relatively large secondary teeth, and sometimes two small ones, well back from the tip. (Fig. 19). Inside the claw is a cavity which extends from the tip back to a partition directly under the larger secondary tooth. This cavity appears to be lined with a thin layer of chitin. Behind the partition is the central cavity which is present in all claws and is caused by the withdrawal, preparatory to the next molt, of the hypodermal cells which have secreted the claw. When these claws were first studied, I assumed that the cavity running to the tip of the claw corresponded to the embolus of the claw of the male, but the absence of any space between the lining of the cavity and the outer wall of the claw makes it difficult to explain the mechanics of its secretion. It is quite likely that the claw figured which belonged to an old female was worn down at the tip and the cavity badly encrusted with dirt. Until specimens which are just ready to molt are obtained and the soft claw can be sectioned, we will not attempt an interpretation. A similar cavity occurs in the palpal claw of the female Dysdera interrita. Viewed from beneath, the claw of the female Brachybothrium shows a decided enlargement (Fig. 20, a) near the base, which appears to be the remnant of the second claw, or, if one assumes that the claw was originally single, this hump may represent a rudimentary second claw.

The palpal organ of the male is not as simple as the similar organ of Eurypelma. Two elongated heavily chitinized teeth (Fig. 21, te.) extend from the center of the claw and support the embolus (emb.). The distal tooth is the longer of the two. On its face is a long groove in which lies the tip of the embolus. The proximal piece extends under the first and holds it in position, though there is no connection between them. They are separate teeth, and are quite evidently homologous to the two found on the claw of the female. Together they form the structure known as the conductor of the embolus (Comstock '10, p. 168).

The claws of the left first foot of the female are shown in Figure 22. There are three claws, the two upper carrying four well developed teeth, the lower single one bearing no teeth. The upper claws are set in a flexible membrane.

Phidippus audax (Hentz).

Most authors state that the attids or jumping spiders have no palpal claw. Wagner (:88) who had apparently made a careful study of the matter, states quite emphatically on page 365, "Le palpe de l'Attus n'a pas le moindre vestige d'un crochet même a l'âge le plus tendre."

In the vicinity of Columbus, Ohio, during the late fall, young males and females of Phidippus audax are easily distinguished by the fact that the males all show the swelling of the terminal segments of the palps and the developing palpal organs, while the female palps show no change. Many specimens have been examined under the binocular microscope. The conditions noted are as follows: On the underside near the tip of the female palp where one would expect to find a claw,

none is visible. Instead there is a small dimple, the edges of which are seen to be thickened. On the end of the male palp in a corresponding position one can discover with very high power and strong illumination a distinct simple claw, which is small and depressed dorsally into the heavy chitin of the segment. At its base is a small pimple of heavy chitin. That this is a true claw equipped with the proper tendons is easily determined from 10μ sections. (Plate XXXVII, Fig. 25, and Plate XLI, Fig. 23). Similar sections of the female palp show the remains of a very much reduced claw (Fig. 24). Although the actual claw was slightly displaced in sectioning, it is shown in position, as nearly as possible, in the figure. The two tendons and the fundament of the claw were not displaced. The claw of the male is pulled well into the chitin; its tip is bent parallel to the surface of the palp. It is peculiar in having several bristles arising on the exposed third and also in showing a cavity extending from the base to the tip. The female claw is very small, only about one-fourth as long as that of the male. Two large tendons unite with it at the base. Between the proximal ends of these lies the fundament of the claw, (cl. f.). In Figure 24 it is shown as it has been retracted, prior to the secretion of a new claw, before the last molt.

The presence of tendons, as well as the fundaments of the claws, in both sexes, together with the obvious claw-like structure of the organs appears to settle the question of the presence of a claw in this species definitely in the affirmative.

ORDER SOLIFUGÆ.

In connection with the study of the palpal claw the Solifugæ offer a good many difficult problems and puzzling characters. In the first place, these interesting animals are so rare they have not been carefully studied, alive. The curious sucker-like protrusible organ at the end of the palp has been described as an adhesive disc or sucking pad, and as an olfactory organ. In the second place, preserved specimens are difficult to obtain for study, and when obtained are found to have such a thick chitinous exoskeleton that they are dissected with difficulty, and are almost impossible to section. My material consisted of one specimen of Datames constricta Putnam, kindly sent me by Dr. Mosher, from Albuquerque, N. M., one specimen which appears to be Cleobis stimpsoni Putnam, from Florida, and three specimens labeled Datames formicaria K. from Lower California, Mex. Whether this species is correctly named or not, I do not know. However, as far as our inquiry is concerned, the names are relatively unimportant because the three species show corresponding structures so much alike that species differences can be neglected. Two palps have been sectioned, three have been dissected under the binocular microscope by means of small knives made from pieces of safety razor blades cemented into small glass tubes.

Our discussion of these animals may well be arranged as follows: First, a comparative study of the structures of the claws and muscles of the chelicerae, palps, and first feet. Second, a description of the minute anatomy of the palpal organ. Third, an attempt to determine

in the absence of direct experimental proof, what the probable function of this organ is.

Structure of chelicerae, palps, and feet.

The chelicerae, as is well known, are remarkably powerful. They are further peculiar in that the chelae open and close vertically, the movable claw being below the spur of the penultimate segment. (Fig. 26). The large muscle, the flexor unguium, which closes the chela is distributed as it is in the scorpions and spiders, in the enlarged portion of the penultimate segment. The extensor unguium is well developed and is similar to the same muscle in the scorpion and spider. It would appear that the organ is quite similar to that of the scorpion except in position. A rotation of the chelicera of the latter through 90 degrees outward, around its longitudinal axis, would give it the position it occupies in the solpugid.

The pedipalps are long, heavy, and leg-like, and are mentioned as being used much as the legs are. The segments are coxa, trochanter, femur, tibia, metatarsus, tarsus and protrusible organ (Fig. 27). The tarsus may be solidly fused to the metatarsus or may be separated to such an extent that it is slightly movable. The metatarsus and tarsus are covered with a thick brush of assorted hairs and scales. The various shapes of these, together with their extensive nerve supply, indicate that they are sensory organs. This interpretation agrees with the observational evidence (Bernard, '96, p. 350).

The protrusible organ at the tip of the tarsus is quite complicated. In some alcoholic specimens it is protruded, in others it is withdrawn into the cavity of the tarsus, (Figs. 27, 28, and 30). One would expect to find that this organ might bear some traces of a claw or other structures of a foot. We will examine this organ with this idea in mind.

A side view of the end of the palp, (Fig. 27), shows the soft chitinous pad of the protrusitle organ fully extended. The two muscles which operate it may be named as they are in the other arachnids, the extensor and flexor unguium. They are connected to the organ in a rather complicated way; but their attachments furnish the necessary clues to work out the homologies of the parts of this organ. The lateral walls of the tarsal segment end in *two* lateral bosses or rounded projections, (Fig. 28, bo.) somewhat similar in structure to those which form the joint between the tibia and metatarsus. Abutting on the upper bosses are two slightly chitinized flaps (cl.) which extend obliquely upward, meet, and join in the mid-line above the pad. The basal part of these flaps is heavily chitinized and fits over the upper boss, being at the same time attached to a vertical bar or plate (pl. 1, Fig. 28). This plate extends downward nearly to the middle of the side of the protrusible pad (p). The inside edge of this vertical plate is joined to a horizontal chitinized piece (pl. 2, Figs. 28 and 29), which connects proximally to the upper tendon, the tendon extensor unguium, and distally with the upper lateral edge of the pad. When the extensor muscle contracts, pulling this chitinized piece inward, the pad is retracted

and the chitinized flaps are pulled downward over the end of the pad. In Datames constricta the flaps are furnished with minute rounded teeth (Fig. 30, te.) below, which probably scrape off sand or other substances attached to the pad as it is drawn in. These flaps are unquestionably the modified claw or claws of the palpal foot. The vertical plate (pl. l.) is probably the lateral plate. Attached to the lower boss is a curved tendon plate (t. pl., Figs. 28, 29 and 30) which extends completely around the underside of the palp. This tendon plate is continued dorsally and anteriorly into a bar (b., Fig. 28) which articulates with the anterior side of the lower end of the lateral plate (pl. l) of the same side. Ventral to this articulation and connected with it is a heavy rim (r., Fig. 28) over which the pad is pulled as it is retracted. When the pad is completely retracted the tendon plate is pulled forward and upward, covering the end of the pad and protecting it, (Fig. 30, t. pl. and p.). When the flexor muscle, which is connected with the tendon plate at its middle (Fig. 30, t. fl. u.), is contracted the tendon plate is lowered, as it is in Fig. 28. The bar (b) pulls the lateral plate forward and pushes the claws upward, leaving an opening through which the pad is forced, probably by the action of air and blood pressure. The functions of flexion and extension exercised by the two muscles operating the claws, pad, and tendon plate, are here easily recognized, although their functioning is complicated, and, as far as the claws themselves are concerned, is the reverse of the usual condition. This arrangement of plates, claws and tendons may be compared to advantage with the arrangement in the pseudo-scorpion foot as shown in Fig. 43.

The first foot of Datames constricta (Plate XXXIX, Fig. 31) bears two long sickle-shaped claws which are peculiar in having tips which are flexed, each by its own branch of the flexor unguium tendon (Fig. 31, t. fl. u.). Between the bases of the claws is either a single or a double pad (empodium), single in D. constricta, double in D. formicaria. The pad does not appear to be movable, though it seems likely that it may be distended by blood pressure. The tendons are similar to those of other arachnids, except that they each bifurcate a short distance before they reach the claws. Each branch of the extensor unguium enters the base of a claw and extends in the cavity on the dorsal side almost to the middle of the claw. At its extremity it attaches to the dorsal wall of the claw. The flexor unguium extends throughout the claw and joins the ventral part of the movable tip. The upper part of this tip is hinged, (Fig. 31, h.) in such a way that the pull of the tendon depresses the whole claw, as well as the tip. The foot appears to be an admirable organ for grasping either rough or smooth projections. The foot is similar in many ways to the feet of both pseudoscorpions and scorpions.

The minute anatomy of the palpal organ.

This organ has been described by Bernard (:96, p. 349). After describing the "lips" (flaps and rim) between which the protrusible organ emerges, he takes up the conditions found in the infolded organ

(compare with Fig. 29) in the following words: "The aperture leads into a deep conical invagination, running through the whole length of the joint, which is free in Galeodes." * * * "The folded walls of the invagination gradually converge, and run down the tibia as a long tendon." * * * "The whole of this chitinous invagination is covered by an epithelium continued down the tendon as far as the muscle, where it becomes lost to sight." * * * "The epithelium covering the inner ventral face of the flattened conical invagination is deep, contains several layers of small nuclei, and is sensory. The sensory cells send fine hair-like processes through the cuticle, which project into the invagination, clothing its ventral wall like a fine velvet. These hairs are about 1μ thick and 75μ long; the surface formed by their tips is wavy, perhaps for the purpose of increase."

"The cuticle, traversed by these hair-like processes, is regularly channelled through by rows of pores close together, so that it has, at times, a net- or lattice-like appearance. It is considerably thickened, perhaps to keep the sensory area spread out. It is, nevertheless, liable to be folded longitudinally, the longitudinal bars of the lattice work being thicker than the transverse. The dorsal surface of this sensory invagination is entirely free from such hairs, and is extremely thin and delicate. When the lips are closed the tips of the sensory hairs rest against this membrane."

Bernard's description of the structure of the protrusible organ of Galeodes is equally good for the similar structures of Datames and Cleobis. His assumption that the epithelium of the protrusible organ is sensory, seems to me to be open to very grave question. He shows no nerve supply for this organ, which, considering its size, should be considerable if it has a sensory function. Furthermore, if "the cuticle is regularly channelled through by rows of pores close together," what is to prevent the animal from losing large quantities of blood?

In order to arrive at an independent judgment, it will be best to describe this whole organ very carefully, and to determine the relations of the blood supply and nervous supply.

The structures of the protrusible organ are most easily studied from longitudinal sections of the organ fixed in the protruded condition. Figure 33, Plate XXXVIII, shows a camera sketch from such a section, while Figure 32, Plate XLI, shows a photo-micrograph of a similar section. Figure 32 shows the finer details of this organ very nicely.

If the tendon extensor unguium is followed outward toward the protrusible pad, it will be seen that it divides fan-like into a large number of thickened ribs (Fig. 33, ri.) which run forward, spreading to right and left, turn downward and backward, and merge together again ventrally into another fan-like extension of the same tendon. Between these ribs are cross thickenings, ("lattice-like") usually set at an acute angle, but probably bent at right angles when the whole fabric is fully expanded. The whole affair is consequently a large, flexible, basket which, when collapsed and pulled inwards by the tendon, folds from the sides toward the center (the folds running parallel to the heavier ribs) and puckers as it is pulled through an opening which

is too small to accommodate it easily. (Compare Figs. 28 and 29). The blood space (b. s., Figs. 32, Plate XLI, and 33, Plate XXXVIII) in the center of the organ is connected, by way of the pores between the ribs, with the center of the pad. This region we will call for lack of a better name the stained area (st. ar., Fig. 33). Reference to Figures 32 and 33 shows that the ribs are made up of hypodermal cells (hyp.) each of which has secreted a long hair (hr.). The hairs are consequently arranged regularly in rows. These hairs are much divided and swollen at their tips, and form a surface much like plush, which is in this case slightly wavy. A short distance inside the outer ends of the hairs is a membrane (m.), wavy like the outer ends of the hairs, and nearly parallel to their surface. This membrane is parallel in general to the hypodermal cells which have secreted the hairs and probably have secreted it. Another explanation for this membrane is possible. It may be formed from blood which has pushed out between the hairs and coagulated at this line. This explanation is less satisfactory than the first, because if the membrane were so formed one would expect it to be much thicker than it is. Bernard shows in Figure 14, Plate 31, these hairs bounded at their tips by a similar membrane, but he neglects to mention it or its function. In my preparations the outer zone (o. z.) of the free hair ends is clear and unstained, while the inner zone (st. ar.) below the membrane is distinctly blued by the haematoxylin stain. Inside the blood space, there is more of this material which I interpret as stained coagulated blood. If the hairs of the stained area are studied under a high power objective, it will be noted that they are more or less encrusted with a flocculent blue material. This blue material (probably blood) is arranged in more or less concentric lines (c. l.) and is most easily seen near the center of the stained area in Figure 32. No nerves or structures which can be interpreted as sense cells are to be found in any of the sections which I have examined. A very large nerve supplies the hairs on the metatarsus and tarsus, but does not continue out into the pad.

Interpretation of the structures and their probable function.

If the structures mentioned above have been correctly seen and identified, it becomes evident that the protrusible organ of the Solifugæ is in reality a modified region of the chitinous exoskeleton of the foot, which forms a flexible pad into which the blood may penetrate, even beyond the hypodermal cells. This pad which has maintained its connection with the tendon extensor unguium can be retracted to an unusual degree into the cavity of the tarsus. The surface of the pad in alcohol has, due to the hairs, the appearance and consistency of silvery white velvet. The pad as a whole is very flexible, cushion-like, and yet not easily torn. When the pad is pulled in, it occupies less space than when distended. The reinforcement of hairs, each firmly attached, together with the tendency to pucker when it is withdrawn, suggest that the organ is admirably adapted to act as a sucking pad. There is some evidence that the hairs may be provided with a sticky substance. The specimen of Datames constricta had several masses of sand grains stuck

to the hairs of the tarsus where the pad would be most likely to strike them. The structure of these pads is not very different from that of other erectile organs found among the insects. The oral lobes of the proboscis of the house-fly, with their pseudotracheae, is a case in point.

The whole protrusible organ of the palp of the solpugid is, I believe, for the reasons given above, a sucking or grasping organ without sensory function. It is clearly homologous to a palpal foot with an enlarged empodium and modified claws. The best evidence that it normally functions as a sucking organ, at least in some species, is given in the Cambridge Natural History in the volume on Crustacea and Arachnids, page 425.

"That their pedipalps, in addition to their sensory function possess a sucking apparatus, is clear from an observation of Lönnberg, who kept specimens of Galeodes araneoides imprisoned in rectangular glass boxes, up the perpendicular sides of which they were able to climb for some distance by their palps, but, being able to obtain no hold by their legs, they soon tired."

ORDER PEDIPALPI.

A single specimen of the whip-scorpion (Mastigoproctus giganteus), rather poorly preserved in alcohol, furnished the material for the following rather meagre study.

The pedipalps are very large, heavy, and curved toward the mouth from right and left. No chela is present, but the heavy spurs from the tips of the segments give the appearance of several chelæ, one following the other. The terminal segment, the claw (Fig. 34, cl.) is small, very heavy, and immovable. Nevertheless two tendons attach to it. They are slender and degenerate. The tendon extensor unguium passes through the penultimate segment and attaches to a few small, atrophied, muscles in the next segment, the metatarsus. This fact aids in naming the three terminal joints, claw, tarsus, and metatarsus, (Fig. 34). By inference the remaining segments reading toward the head will be tibia, femur, trochanter and coxa. This diagnosis agrees with the names used by Kraepelin, :99, page 201. He calls the segment beyond the tibia "hand" and the two following "finger," evidently overlooking the division of the "finger" into tarsus and claw. The tendon flexor unguium was traced through the tarsus and metatarsus, but was lost in the mass of torn muscles in the tibia.

The chelicerae are much like those of the primitive spiders. They are chelate, the movable finger or claw moving vertically, operated by the usual muscles (Fig. 35). The flexor unguium attaches to a large plate, (t. pl.), the tendon plate. Comstock ('12, p. 102) calls this plate, in spiders, the "articular sclerite" and follows Bernard in suggesting that it "may be a vestige of an intermediate segment." With this view I cannot agree, as will appear below.

The first leg is long and slender. Two tendons extend proximally from the very much reduced claws through nine tarsal segments into what appears to be the long metatarsus. Since the muscles had separated from the tendons, it was impossible to trace these tendons to their origin.

ORDER ACARI.

This order, including the host of species of mites and ticks, shows a wide range of variation in the structures of the chelicerae, pedipalps, and legs. In general, one may say that the chelicerae are two or three jointed, often showing a claw at the tip, though in many forms they are so reduced that it is difficult to distinguish these parts. Some are chelate. In one genus, Rhagidia, (Banks, '15, Fig. 13) the chelicerae and other structures of the body seem to indicate a close relationship with the solpugida. The pedipalps are usually five or six jointed, solidly united together at the base, much as they are in the Uropygi, (Hansen and Sorensen, '04, p. 124). The palp may bear at the tip spines, hairs, or one or two claws, or these structures may be reduced to a very considerable extent.

The legs are composed of five, six, or seven segments, usually named in order coxa, trochanter, femur, patella, tibia, and tarsus. In some, the femur may be divided, forming a trochantin like that found in the Solpugida. The tarsus usually bears from one to three claws, and a highly specialized sucking empodium may be present. Banks shows on page 60 of his review of the Acarina or Mites (Banks, '15, Fig. 112) the claws and pulvillus of Margaropus annulatus, which superficially at least, reminds one strongly of the protrusible organ of the solpugid.

Only two examples will be used to illustrate this order of the Arachnida. It must be understood that the material given below cannot well be considered representative of the whole group.

PODOTHROMBIUM sp.

The specimens studied were of a large species of red mite belonging to the genus Podothrombium. The palps (Fig. 36), which are strongly curved downward over the mouth, are extremely robust and exhibit the most peculiar arrangement of structures which I have seen in any arachnid, excepting possibly the palps of the solpugid. The palp appears to terminate in a heavy claw. Until a specimen is cleared and mounted, one feels certain that this "claw" is clearly terminal, and that the "thumb" is really an empodium. A study of the cleared specimen shows that the claw is a specialized tip of the immovable finger of the penultimate segment, while the movable finger instead of being narrow and pointed, is club-shaped. The muscles which operate it both join the proximal side of the thumb, so that when moved, the force of this segment is exerted toward the mouth, in the general direction of curvature of the whole organ, instead of toward the immovable finger. The extensor unguium arises in the penultimate segment. Hence, this may be designated the metatarsus. A longer muscle, the flexor unguium, extends through to the penultimate segment, the tibia. The three basal segments will then be the femur, the trochanter, and the coxa. It would be interesting to know how the thumb (claw) and the false claw are used. One can surmise only that they are used in holding objects before the chelicerae while they are being cut up by the claws of these organs.

The chelicerae (Fig. 37) consist of two segments and claw. The basal is very broad and contains two sets of muscles; one set serves to raise the claw and second segment dorsally, while the other serves to lower the second segment and claw. The segment is long, very heavily chitinized, and contains muscles which work the terminal claw. This claw is peculiar in that it is concave dorsally, that is, it moves dorsally when flexed. The dorsal edge is extremely sharp and is armed near the tip with fine serrations. The complete rotation of the claw, and probably of the whole organ is further emphasized by the fact that the flexor unguium is very large and powerful, while the extensor unguium is much smaller.

The first leg (Fig. 38) contains seven segments, and is quite typically arachnid in form and structure. An examination of Fig. 38 will show that the muscles are arranged in a very uniform way. Beginning with the femur and extending through the patella, tibia and metatarsus, the muscle which arises in the vicinity of the joint, on the dorsal side of the leg, passes through the next segment, and inserts on the lower proximal edge of the third. The extensor unguium and flexor unguium are the two terminal muscles of this series. Their insertion into the claws indicates that the claws are to be considered either a terminal segment, or two terminal segments combined.

Dermacentor venustus.

The chelicerae of this tick show two basal segments with heavy terminal claws turned outward. The two tendons, the extensor and retractor, extend posteriorly to muscles situated in the basal part of the appendage. The muscles of the flexor unguium continue into the body of the animal, evidently serving to retract the whole organ when the claw is flexed laterally.

The palp consists of three very heavy, short segments with a fourth which is much reduced and set into the tip of the third. The claws are reduced either to heavy spines, or have disappeared. As no tendons run through the terminal segment, it is possible that this segment represents the claw.

The forelegs consist of the usual six segments. The terminal segment is almost cut in two just in front of Haller's organ. This probably represents a tarsal segment. The terminal claws and pulvillus are complicated in structure, but so thinly chitinized that they appear to be absolutely useless. Their function as locomotor organs has been taken over by the pointed projections on the terminal segments of the legs. The tendons running to the claws are very minute, and apparently have lost their function.

ORDER PSEUDOSCORPIONIDA.

The animals in this order seem to show many affinities with the solpugids, although superficially they resemble the scorpions much more closely. My specimens were not numerous enough to enable me to study a large series of individuals of one species, so that it became necessary to use three species belonging to two different genera. This

proved to be fortunate, for specimens of Chelanops show characters of the feet and movable finger of the pedipalp which could not be found in the two species of Chthonius at hand. Undoubtedly if more material were available other interesting structures, or variations of structures, could be found.

The chelicerae in all species so far recorded are two jointed and chelate. In Chthonius sp. (Fig. 39) they are very large and heavy. The movable claw is unguiculate, that is, the terminal claw is divided into a serrula (Ser., Fig. 39) and the stouter movable finger (cl.). These two structures seem to be homologous though somewhat different in form. The movable finger bears near its tip the opening of the spinning gland, (sp. gl.). The muscles which move the claws are evidently comparable to those of other arachnids. The spinning gland with its duct and opening appears to be homologous to the poison apparatus of the spider.

The pedipalp (Fig. 40), which is very long, terminates in a slender chela. Its six segments, coxa, trochanter, femur, tibia, metatarsus, and claw, are similar to those found in the pedipalp of the scorpion, (Fig. 5), even to the arrangement of the muscles which move the claw. These organs are too small to dissect. Consequently the observations recorded are from cleared whole mounts. In Chthonius there seems to be no gland or invaginated sac in the movable finger, although my specimens appeared to be either females or young. It is possible that males might show such an organ. One specimen of Chelanops (morosus?) and one of Chelifer virginianus showed in the movable finger, (Fig. 41) such a sac-like organ with its chitinous duct and opening. So far as I can learn, this organ has not been described from the Pseudoscorpions up to this time. The inner end of the chitinous duct is enlarged and changes abruptly into a much larger folded sac which shows transparent but well defined walls. The organ is full of granular material which cannot be identified. Until more specimens of this species, both males and females, can be studied, it is useless to speculate about its function. If it should be found only in males, we would have here a most curious homologue of the palpal organ of male spiders.

The first legs of Chthonius sp. were difficult to study because of the thick covering of long hairs. The first leg of Chelanops (morosus?) (Fig. 42), however, shows, when cleared, the segmentation and muscles with fair distinctness. The segments of the legs are typically, coxa, trochanter, femur, (which may be divided at its base to form a trochantin as in the figure), tibia, metatarsus, and claws (including the large empodium). The claws of this foot (Fig. 43) show the same plates which we have already noted in the foot of the spider and solpugid. The presence of the empodium or pad in the pseudoscorpion foot, arising from the thin membrane between the two claws and tendon plate, indicates that the pseudoscorpion foot remains in the more primitive condition from which the protrosible organ of the solpugid may be supposed to have arisen. One is tempted to see in the empodium of the pseudoscorpion foot a blood cavity and connections with the tendon of the extensor unguium muscle, (Fig. 43). The cleared preparations

however are too small and complicated to be serviceable for these finer details which must be left for a special study. It should be noted that the curved claw of the foot of the spider is not homologous with the sucker of the pseudoscorpion foot but with the tendon plate. Hence, if the name empodium is used for the claw, it must not be used also for the sucker.

Discussion of Part I.

The palpal claw of arachnids, except in the Palpigradi and possibly the Solpugida is single. In this respect and in this respect only, it differs from the claws of the feet of most arachnids. It agrees with the claws of the chelicerae of most arachnids in being single. Exceptions to this agreement being noted in the Scorpions, some Pseudoscorpions and the ticks, where the claw of the chelicerae is divided or partially divided. We have already noted that the claws of Crustacea, including the Trilobites and the early scorpions consist of only one segment. De Meijere, '01, page 461, notes further that the same conditions obtain in the Myriapods, and in certain insects, notably Pediculidæ, Coccidæ, a few Coleoptera and in Belostoma (first feet) among the Hemiptera. His comment, "Da stellt die Kralle selbst fast das ganze Endglied dar," is significant. It appears further from dissections which I have made of several stages of Lachnosterna larvae and pupae that the claw segment which is single in the larva becomes split during the early pupal period forming directly a double claw. We have shown above also that the end segment of the palps in the pseudoscorpions and scorpions is directly homologous, even to the invagination in the former, with the similar but modified claw of the male spider.

From this only one conclusion is tenable; namely, that the claws of the arachnids, both those of the palps and feet, have arisen from the single terminal segments found in the ancestors of the group. The arachnid types studied show no conditions which will warrant us in following De Meijere in his assumption of a pretarsal segment and claw. It seems best to call the foot one segment and to study its modifications from this standpoint. In arriving at this conclusion we follow the lead of Milne Edwards and others, including De Meijere, who have made earlier attempts to decide between the two possible hypotheses of the origin of the double claws of certain arthropods.

It was not the original intent in planning this paper to take up the structure of the arachnid foot. The structures of

these feet, as well as those of the tarsal segments, metatarsus and tibia, and the proper muscles and tendons, forced themselves on our attention. They will be summarized in the final conclusions at the end of the paper.

PART II. THE DEVELOPMENT OF THE PALPAL ORGAN OF MALE SPIDERS.

PREVIOUS WORK.

Wagner, (:88), in his contribution "La Mue des Araignées," discusses two topics which have a considerable bearing on the problem in hand. In discussing the palpal claws and their teeth during the successive molts, he notes that the teeth of the palpal claws may decrease in number in both sexes, as the last molt approaches. On page 365 he makes the following statement concerning Lycosa: "Vers l'époque de la maturité sexuelle d'un male, le crochet même s'est transforme en épine; chez la femelle il est resté presque invariable. Dans ce sense par conséquent la femelle a subi moins de modifications que le mâle."

In discussing the development of the palps of the males and females, and the earliest stages of the palpal organ, he describes the general characteristics of these organs correctly, but fails to trace the fundament of the palpal organ back beyond the stage where it appears in the cymbium as a pappilla "de la matrice," the apex of which is directed toward the front. From what will appear below it seems very remarkable that he should have failed to note its relation to the claw of the palp.

Several authors have noted a single spine or hair which may remain at the tip of the palpus of the mature male spider in the place where the claw stood. Many have noted the absence of the claw on the palpus of most mature males. No one, so far as I can learn, has attempted to determine the origin and early development of the palpal organ.

In attempting to study this problem, I collected a good many young male spiders, and made a good many serial sections and dissections, without finding a form suitable for study. It is relatively easy, for instance, to get a long series of males of Pardosa nigropalpis Emerton. The chitin, however, is too thick to be easily sectioned, and the palps are too small to be easily oriented for sectioning. The fortunate discovery, however, of a large colony of Steatoda borealis (Hentz) finally settled the question of a satisfactory amount of material which could be easily sectioned.

METHODS.

The spiders were dropped into Henning's Fluid, where they were allowed to remain for about half an hour. The specimens were then changed to 70% alcohol and iodine and washed until the iodine was no longer decolorized. Just before imbedding, a slight incision was made through the wall of the palp. Sections were made in paraffin usually

about 7μ thick. The best orientation was secured by allowing the whole palp to lie on the bottom of the imbedding box, while the paraffin was cooled. The palp, when it was killed, usually bent itself into the shape of a triangle, so that when sections were cut parallel to the bottom of the block, in most cases they were parallel to the axial plane of the palp. The sections were stained on the slide with Delafield's Haematoxylin (10% aqueous solution), and were counterstained with eosin in 95% alcohol.

Steatoda borealis (Hentz)

The material was divided into five stages corresponding roughly to the five most easily recognized degrees of development of the palpal organ.

MALE PALP—STAGE I.

Until the palp of the young male begins to swell, it is impossible to determine the sex of the different individuals. Consequently Stage I is represented by those specimens which show a slight swelling of the palp. Figure 46 shows a section of such a palp. The swelling involves the whole organ, as if it had taken in an unusual supply of blood. The hypodermis is in contact with the exoskeleton, although the hypodermal cells are evidently increasing in numbers, and a certain amount of folding of the hypodermis is evident. The claw is terminal. Part of it has been cut away, but remains in another section. At least eight minute teeth, counting the terminal, are visible. This count compares very favorably with that of the mature female claw shown on Plate XL, Fig. 44. The tip of the fundament of the claw (cl. f. Fig. 47, and Fig. 52), extends into the base of the claw. This fundament has already started to secrete either a molting fluid or chitin even before it has been fully withdrawn from the base of the old claw. Traces of the two tendons which are beginning to form are to be seen proximal to the fundament, (Fig. 50, t. exu.). Wagner has pointed out that in the feet the hypodermal cells, or possibly the mesenchyme cells, gather around the old tendons, and secrete the new tendon material around the old, in such a way that when the outer skin and old claw is shed, the old tendon pulls out of the center of the new one, leaving a cavity which is often visible at the end, and shows clearly in sections. My observations confirm this view and indicate that the same method of operation is carried out in the formation of new palpal claw tendons. In Fig. 50, which is an enlargement of the tip of the section shown in Fig. 46, the blood septum (b. sept.) is visible. It will be noted that this septum is some little distance below the present hypodermal layer, and that no blood cells and little coagulated blood occupies the intermediate space. This septum appears to be non cellular. It is a clearly defined layer which extends down the whole length of the palp, except where new muscles push it against the under side of the hypodermal layer of cells. It appears to be chitinous in composition. It joins the base of the claw fundament on both sides.

THE FEMALE PALP.

Sections of female palps were made in order to determine the conditions which obtain in the palp which is undergoing no unusual metamorphosis. The females from which these palps were taken were evidently preparing to shed. They were taken from the colony mentioned above at the same time as the males were, and treated in exactly the same way, so that their structures can be legitimately compared with those of the males.

Figure 48 shows a section of the female palp and claw, while Figure 49 shows the tip of the same, much enlarged. It will be seen at once that the claw fundament is smaller than it is in the male, and is also quite different in shape. At its anterior end it is secreting chitin. At its center, the cells are deeply invaginated, forming a long, cone-like mass which is hollow, at least near the anterior end. The blood septum, like that seen in the male palp, is visible, but it is pressed close to the base of the hypodermal cells. This would seem to indicate that the circulation, or at least the blood supply, in the male exceeds that in the female. The claw bears eight teeth. Sections nearer the center of the palp show both flexor and extensor tendons and muscles in the process of being formed. Neither tendon connects with the invaginated cone of the claw fundament. Another specimen shows identical conditions except that the claw bears only five teeth.

Male Palp—Stage II.

In this stage the old skin has separated from the hypodermal layer. The hair cells have secreted soft new hairs, (hr., Figs. 47 and 51) which lie nearly parallel with the surface of the hypodermis. The claw fundament has been pushed back or possibly pulled back into the tip of the tarsus. The material secreted by the claw fundament has become more dense and is taking on more the appearance of a claw. No definite invagination of cells comparable to that seen in the female fundament is visible. Both the flexor and extensor tendons are being formed rapidly and the corresponding muscles are beginning to show clearly in certain sections. One section shows the old tendon flexor unguium attached to the base of the old claw at the outer end, but extending inward through the fundament and into the new tendon at its inner end. It is unfortunate that this palp was not so oriented that this tendon showed in the photograph.

Male Palp—Stage IIa.

This stage, while only slightly advanced beyond the condition shown in Stage II, shows the new claw well developed and the claw fundament much enlarged and much longer than in the younger stages. This stage shows also the cellular elements in the palp to good advantage. Figure 54 represents a part of this stage much enlarged. It will be noted that the central cavity is filled with blood cells (b. c.) and a mass of coagulated material, which is probably blood albumen.

Male Palp—Stage IIb.

In this individual the time for molting was very near at hand. The hairs (Fig. 53) and claw (cl.) have turned yellowish brown. The claw fundament is very large and much elongated. The new claw itself shows only one long and two short teeth. The ventral side of the claw fundament, just above the place where the tendon flexor unguium unites with it, shows a peculiar whirl of cells which may represent the earliest stage of the development of the peculiar invagination (inv., Fig. 53), which appears definitely in the next stage. The tendons which attach to the claw are fairly well developed, but the muscles are represented merely by a few small fibers.

Male Palp—Stage III.

Immediately after the molt in which the old claw with five to eight teeth has been shed, the tibia and metatarsus are very much swollen. In fact the distal end of the palp is nearly spherical. The new claw at the tip in this specimen is without teeth (Fig. 55). The central blood space is much enlarged and is filled with thousands of blood cells and much granular material. The blood space surrounding the central mass is also enlarged, but contains very few cells except those from the hypodermis, which are now widely separated from each other. Figure 56 shows an enlarged view of the claw fundament from a section close to the one shown in Figure 55. This figure shows the attachment of the fundament to the metatarsus into which it is sunken. It lies now in the cavity which in the mature palp becomes the cymbium (cy). The lower part of the claw fundament includes what now appears as a clear cut invagination (inv., Fig. 56). One frail tendon, the extensor unguium, extends inward from the new claw, but the other is not visible. The tendon cells attached to the fundament at its base are so irregular that it is difficult to determine whether new tendons are developing or not.

Male Palp—Stage IV.

This stage is separated from Stage III only by the fact that the fundament of the claw has now reached a stage of development in which it is obviously the developing palpal organ. Figures 57 and 58 show sections of palps in this stage. In Figure 58 it will be noted that the fundament of the palpal organ (p. o. f.) shows the beginnings of several divisions which probably are equivalent to the several teeth which would normally develop on the claw. The invagination (inv.) shows clearly, but is shown much better in Fig. 59, which is an enlarged view of another section from the same slide. In this figure the invagination has pushed inward horizontally, and then made a right angled turn upward, where it comes to a blunt end. The tip of the fundament is apparently secreting a slight amount of chitin; but it is doubtful if this organ secretes another single claw before it reaches its mature condition at the next molt. The cells which join the base of the fundament of the palpal organ, and extend backward through the mass of blood cells, indicates that at least one tendon is being secreted. This tendon does not appear

in the sections photographed. The hypodermal cells around the base of the palpal organ (Fig. 58) are developing rapidly; but the hypodermis of the rest of the palp shows almost no activity. Muscle development is proceeding rapidly in the femur and patella (fem. and pat.), but only slight traces of muscle cells are to be noted in the tibia and metatarsus.

Male Palp—Stage V.

Stage V, represented by Figures 60 and 61, shows the most advanced condition which is represented in my material. Figure 60 shows the claw badly shattered in position. Directly underneath it lies the elongated tip of the palpal organ which is beginning to secrete a small amount of chitin. Figure 61 shows another section from the same slide, in which the invagination, which is really the receptaculum seminis, (r. s.) has been cut across at three different places. When the sections of the fundament in this stage are plotted by means of the camera lucida, one above the other, it becomes clear at once that the receptaculum seminis starts on the ventral side of the point of the fundament shown in Figure 60, runs ventrally a short distance, (r. s. 1, Fig. 61) then turns downward abruptly and comes upward further back in the fundament, (r. s. 2, Fig. 61). From this point it curves upward, and to the right turning downward and ending bluntly, (near r. s. 3). This receptaculum seminis is a distinct tube, at least in parts of its course. The fundament of the palpal organ in this stage shows quite clearly that projections, or teeth, are forming on the anterior part of its surface. The most prominent of these teeth is the tip of the fundament.

Stage VI.

No material was obtained which would bridge the gap between stage V and the mature palpal organ of the male. It will be necessary, therefore, to assume that the developing palp does not undergo any radical changes during this period except the elongation of the teeth which had already started to develop, and the elongation of the receptaculum seminis inside the palpal organ, together with the secretion of a large amount of chitin over the surface of the whole organ. Figure 45, Plate XL, shows a camera lucida drawing of the mature palpal organ after it had been relaxed by boiling in K O H solution and cleared in cedar oil. It will be noted that the longest projection, which probably represents the first tooth (1, Fig. 45) and corresponds to the tip of the female claw, (Fig. 44) is the embolus (emb.) and contains the terminal portion of the receptaculum seminis. The tooth nearest the base of the embolus (2, Fig. 45) probably represents the second tooth of the male claw, if the principle which we attempted to establish in discussing the palpal organ of Brachybothrium pacificum can be used in this case. It will be noted that this tooth is second in length of the four which are visible. The third tooth lies underneath the second, which curves over it, and is much shorter. The fourth (4) is represented by a knob or bulge on the palpal organ. As the organ is represented in Figure 45, after being straightened, one fails to realize the extent to which it has been twisted in its development. An attempt to study the organ in its

natural position, however, brings this out very clearly. It now appears certain that the twisting of the whole organ together with the fantastic shapes which the teeth assume, has obscured the fact that these organs are modified claws, and has led to the considerable amount of confusion which exists in the names which are applied to their several parts. It is equally obvious that Comstock's nomenclature, particularly the terms "terminal apophysis, median apophysis," and the "tegulum," etc., may need to be revised for these spiders in which the claw shows more than three teeth or three separate divisions. We shall not attempt here to suggest how this matter may be eventually worked out.

Lycosa nidicola Emerton.

In sectioning several specimens of Lycosa as part of the preliminary work on this problem, a lucky orientation gave a few sections of the palp of Lycosa nidicola which showed the main structures in fine shape. Figure 62 is taken from one such section. Here are shown in the same plane, the base of the old claw (cl.) the two tendons (t. exu. and t. fl. u.) which surround the palpal organ (p. o.), the cymbium (cy.) and the extensor muscle (ex. u.) with its attachment to the dorsal wall of the metatarsus. Figure 63 shows in greater detail the tendons and base of the old claw. It will be noted that in this species the fundament of the palpal organ is secreting no chitin. Probably this organ develops completely during the time intervening between the last two molts.

Phidippus audax (Hentz).

We have already determined that a small claw is present in both sexes of this species. In the young male the tip of the palpal organ develops directly underneath the base of this claw (p. o., Fig. 23, Plate XLI). The invagination (inv.) is also easily recognized in sections of these palps. In males in still younger stages the palpal organ is much smaller and is centered very close to the base of the claw. In the mature palpal organ of this species the development of secondary teeth (not the embolus) is inhibited. This might be expected in a form in which the palpal claws are so much reduced in size.

Discussion and Summary of Part II.

The facts presented in this part are clear cut and in such good agreement with the facts obtained in Part I that we are forced to conclude that the palpal organ of male spiders is a modified claw which is retracted a short distance from the tip of the metatarsus where it develops in young individuals. This retraction varies in different species, being less in the more primitive forms (Nelson, Comstock). The teeth of this palpal claw undergo first a reduction in numbers either just before the metamorphosis occurs (Wagner) or during its progress and then a hypertrophy which results, in many forms, in the production of

several, highly specialized teeth and other structures, including the haematodocha, associated, at the same time, with a twisting and enlargement of the whole organ. One fact which seems incompatible with this interpretation should be examined. In certain Lycosidæ what appears to be a claw remains at the tip of the palpus which bears the developed palpal organ. I have not been able to examine this structure except in Pardosa nigropalpis (Emerton). Here, after the retraction of the palpal organ there appears a short but robust, pointed, curved, hair having a broad, circular base. It seems to be intermediate between a claw and a hair. Examination shows, however, that it has no basal tendon connections and is clearly not a claw. Possibly it arises from some cells of the claw fundament which are not withdrawn with the larger mass at the beginning of the claw metamorphosis. The presence of this hair or spine forms no real objection to the interpretation given in this paper.

CONCLUSIONS.

From the evidence presented in this paper and others which are reviewed herein, we may draw the following conclusions:

1. The palpal claw of arachnids, including its associated structures, the whole, perhaps better called the foot, represents a single primitive segment comparable to that of the dactylopodite of the Crustacea.

2. In several orders of the arachnids, the palpal claws are very differently specialized. In spite of this specialization, certain parts are differentiated in such a similar manner that their homologies are easily seen.

3. The palpal organ of male spiders is a hypertrophied palpal claw which has undergone a post-embryonic development in which an invaginated tube of cells makes its appearance, and the teeth of the claw take on new shapes. The invagination becomes the receptaculum seminis. It appears to be homologous to the empodium of other arachnid feet. The modified teeth become the accessory structures of the organ, and are known by different names, for example: embolus, terminal apophysis, conductor of the embolus, etc.

4. The palpal claw (foot) and the feet of the other arachnid legs show several easily identified structures which may be defined as follows:

(a) The tendon extensor unguium—A tendon which normally joins the dorsal side of the single or split claw, and extends it. It is degenerate in some forms; shifted in position, in others; in some, it splits, sending one branch to each claw.

(b) The tendon flexor unguium—A tendon which normally joins the under side of the single or split claw. It is usually present. It may join a tendon plate, or may split sending branches into each claw.

(c) The tendon plate—A heavy, chitinous plate on the ventral side of the claw segment, joined to the tendon flexor unguium proximally, and to the membrane in which the claw or claws are set, distally.

(d) The lateral plates—A pair of chitinized lateral plates, represented by thickenings; in some forms, fused with the tendon plate and claws; in others, separate and distinct.

(e) The ungues—The single or split, curved or straight, nail-like ends of the terminal segment; in some forms entire, in others, bearing teeth.

(f) The basal plates—The rod-like plates which bound the proximal end of the claw segment. These may be either a continuous rim of chitin, (Scorpionidæ, etc.) or one or two pairs of vertical plates. Sometimes they are reduced to near the vanishing point.

(g) The pseudonychium—A third claw which appears as a specialization of the tendon plate.

(h) The empodium—An evaginated or invaginated sac formed from the membrane either on the underside of the claw, or between the bases of the split claws and the tendon plate.

(i) The joint membrane—The thinly chitinized membrane of the joint.

5. None of the appendages studied presented evidence to warrant the assumption that two segments make up the terminal claw, or that this segment has split off segments in the same way that the metatarsus has.

6. The peculiar relations of the terminal segment to some of the other segments makes it possible to define the following for the Arachnida:

(a) The claw—The terminal segment of the palps or legs, operated by extensor or flexor tendons, or both.

(b) The tarsus or tarsi—Distinct or partly separated segments through which the extensor and flexor unguium tendons or muscles extend without attachment. These segments are separated from the distal end of the metatarsus.

(c) The metatarsus—The segment in which the extensor unguium muscle has its origin, but through which the flexor unguium extends without attachment, or with only partial attachment.

(d) The tibia—The segment in which the flexor unguium muscle shows its most proximal attachment.

BIBLIOGRAPHY.

Banks, N. '15. U. S. Dept. of Agri. Report No. 108.
Berlese, A. '09. Gli Insetti, Vol. I. Societa Editrice Libraria, Milano.
Bernard, H. M. :96. Trans. Lin. Soc. London. 2nd Series, Vol. VI.
Bordage, E. :98. Ann. Soc. Ent. de la France, Vol. 67.
'00. Ann. Soc. Ent. de la France, Vol. 67.
'05. Bull. Scient. de la France et de la Belgique, Vol. 39.
Brindley, H. H. :98. Proc. Zool. Soc. London, pp. 924–958.
Comstock, J. H. '10. Ann. Ent. Soc. of Amer., Vol. 3, pp. 161–185.
'12. The Spider Book. Doubleday, Page & Co., New York, N. Y.
Friedrick, P. '06. Arch. f. Ent. mech., Bd. 20, p. 469.
Hansen, H. J., and Soerensen, W. '04. On two Orders of Arachnida, Cambridge Univ. Press, London.
Hewitt, C. G. '14. The House Fly. Cambridge Univ. Press, London.
Hirschler, Jan. '03. Anat. Anz., Vol. 23.
Kraepelin, Karl. :99. Scorpiones und Pedipalpi. Das Tierreich, Vol. 8.
Meijere, J. C. H. de. '01. Zoologische Jahrbücher (Anatomie) Bd. 14 : p. 417–476.
Montgomery, T. H. '03. Proc. Acad. Nat. Sci. Philadelphia, pp. 59–149.
Morgan, T. H. '02. Anat. Anz., Vol. 17 and 20.
Nelson, J. A. '09. Ann. Ent. Soc. Amer., Vol. 2, pp. 60–64.
Ockles, Alfred. :90. Archiv. f. Naturgeschickte, Bd. 56, I, pp. 221–262.
Oppenheim, S. '08. Zool. Anz., Bd. 33, May 26.
Petrunkevitch, A. '09. Ann. Ent. Soc. Amer., Vol. II, no. 1, pp. 11–20.
'13. Conn. Acad. of Arts and Sciences, Vol. 18, pp. 1–137, June, 1913.
Smith, C. P. '08. Ann. Ent. Soc. of Amer., Vol. 1, No. 4, pp. 207–236.
Wagner, W. '88. Ann. Sci. Nat. (Zool.) Paris, Vol. 6, pp. 281–393.
Walcott, D. C. '18. Smithsonian Misc. Coll., Vol. 67, No. 4.

EXPLANATION OF PLATES.

Abbreviations Used on the Plates

b.....bar
b. c.....blood cells
bo.....boss
b. s.....blood space
b. sept.....blood septum
cav.....cavity of claw
ch.....chitin
ch. ex.....chitinous exoskeleton
c. l.....concentric lines
cl.....claw
cl. f.....claw fundament
co.....coxa
con.....conductor of the embolus
cy.....cymbium
du.....duct
emb.....embolus
emp.....empodium
ex. m.....extensor metatarsi
ex. u.....extensor unguium
fem.....femur
fl. m.....flexor metatarsi
fl. m. b.....flexor metatarsi bilobatus
fl. m. l.....flexor metatarsi longus
fl. p. b.....flexor patellæ bilobatus
fl. p. l.....flexor patellæ longus
fl. u.....flexor unguium
f. t.....flexor tibia
h.....hinge
hr.....hair
hyp.....hypodermis
j. h.....jointed hairs
j. m.....jointed membrane
l. pl.....lateral plate
m.....membrane
met.....metatarsus
o.....opening
o. sp. gl.....opening of spinning gland
o. z.....outer zone.
p.....pad
pat.....patella
p. d.....poison duct
p. gl.....poison gland
p. o.....palpal organ
p. o. f.....palpal organ fundament
pr. o.....protrusible organ
r.....rim
ri.....ribs
r. pl.....rodlike plates
r. s.....receptaculum seminis
s.....sac
ser.....serula
sp. gl.....spinning gland
st. ar.....stained area
tar.....tarsus
te.....teeth
t. ex. u.....tendon extensor unguium
t. fl. u.....tendon flexor unguium.
ti.....tibia
t. pl.....tendon plate
tr.....trachea
trin.....trochantin
tro.....trochanter

Plate XXXV.

Fig. 1. Right pedipalp of female Limulus polyphemus, two-thirds natural size.
Fig. 2. Right pedipalp of male Limulus polyphemus, two-thirds natural size.
Fig. 3. Right chelicera of female Limulus, dissected to show the muscles which move the claw.
Fig. 4. Terminal segments of right pedipalp of a female Limulus, dissected to show the muscles, natural size.
Fig. 5. Ventral view of the left pedipalp of the Scorpion Hadrurus hirsutus.
Fig. 6. Dissection of the three terminal segments of a scorpion pedipalp showing the muscles.
Fig. 6a. A detail of Fig. 6, showing the insertions of the extensor unguium muscles and tendon flexor unguium.
Fig. 7. A dorsal view of the right chelicera of a scorpion, dissected to show the muscles.

Plate XXXVI.

Fig. 8. A view of the second right leg of a scorpion dissected to show the muscles and tendons.
Fig. 9. Line copy of Fig. 10, Plate VII, from Hansen and Sörensen, showing the left mandidular palp of Cryptostemma crassipalpe (×32); a, first trochanterial part; b, second trochanterial part; c, femoral part; d, tibial part; e, tarsal part.
Fig. 10. A view of the tip of the left pedipalp of Scotolemon flavescens. (× 42).

Fig. 12. Right pedipalp of female Eurypelma californica, dissected to show the muscles and tendons. (× 2).
Fig. 13. Terminal segments of the right pedipalp of a male Eurypelma californica, showing muscles and tendons.
Fig. 14. Right first foot of a female Eurypelma californica, dissected to show the muscles and tendons. (× 3⅓).
Fig. 15. Right first foot of a female Eurypelma californica, boiled in KOH, to show thickened chitinous portions. a, lateral thickening; b, c, rod-like thickenings. (× 70).

PLATE XXXVII.

Fig. 16. Right side of the right chelicera of Eurypelma californica, dissected to show muscles, tendons, poison gland and poison duct. (× 4⅘).
Fig. 17. Left palpus of male Brachybothrium pacificum. (× 6⅘).
Fig. 18. Left palpus of female Brachybothrium pacificum. (× 6⅘).
Fig. 19. Left palpal claw of female Brachybothrium pacificum. (× 85).
Fig. 20. Ventral view of palpal claw of female Brachybothrium. a, knot on posterior side of claw which probably represents the posterior claw.
Fig. 21. Left tarsus and palpal organ of male Brachybothrium pacificum. (× 20).
Fig. 22. Left front foot of female Brachybothrium pacificum. (× 42).
Fig. 24. Camera drawing from a section of the tip of the palpus of a young female Phidippus audax, showing claw, tendons, and fundament of claw. Details have been added from sections on either side of the one drawn. (× 320).
Fig. 25. Camera drawing of section shown in Fig. 23. (× 320). This shows the tarsal claw of the young male Phidippus audax, with its tendons and palpal organ fundament.

PLATE XXXVIII.

Fig. 26. Lateral view of right chelicera of Datames formicaria, dissected to show the muscles. (× 9½).
Fig. 27. Camera drawing of the pedipalp of Cleobis stimpsoni Putnam, with the flexor and extensor muscles shown in diagrammatic fashion.
Fig. 28. End of palp of Datames formicaria with the protrusible organ partly withdrawn. Pl. 1, vertical plate; pl. 2, horizontal plate.
Fig. 29. A dissection of the palp of Datames formicaria, to show the internal connections of the pad. Pl. 2, horizontal plate, etc.
Fig. 30. End view of palp of Datames constricta, showing claws and plates.
Fig. 33. Camera lucida sketch, to show the relative positions of the parts of the expanded pad of Cleobis stimpsoni Putnam.

PLATE XXXIX.

Fig. 31. A side view of the foot of Datames constricta, showing the tendons in the nearer claw.
Fig. 34. Right pedipalp of Mastigoproctus giganteus, seen from below. Free-hand sketch.
Fig. 35. Chelicera of Mastigoproctus giganteus. Camera drawing.
Fig. 36. Right palp of Podothrombium sp.
Fig. 37. Right chelicera of Podothrombium sp., seen from inside.
Fig. 38. Right first leg of Podothrombium sp. (× 186).

PLATE XL.

Fig. 39. Freehand sketch of chelicera of Chthonius sp.
Fig. 40. Pedipalp of Chthonius sp. Camera drawing.
Fig. 41. The movable finger of the palp of Chelanops (morosus?). Camera drawing.
Fig. 42. First leg of Chelanops sp. Camera drawing.
Fig. 43. Foot of Chelanops sp. Camera drawing. (× 320).
Fig. 44. Palpal claw of female Steatoda borealis. Camera drawing. (× 320).
Fig. 45. Palpal claw (expanded) of male Steatoda borealis. Camera drawing; 1, first tooth of claw; 2, second tooth of claw; 3, third tooth of claw; 4, fourth tooth of claw. (circ. × 38).

PLATE XLI.

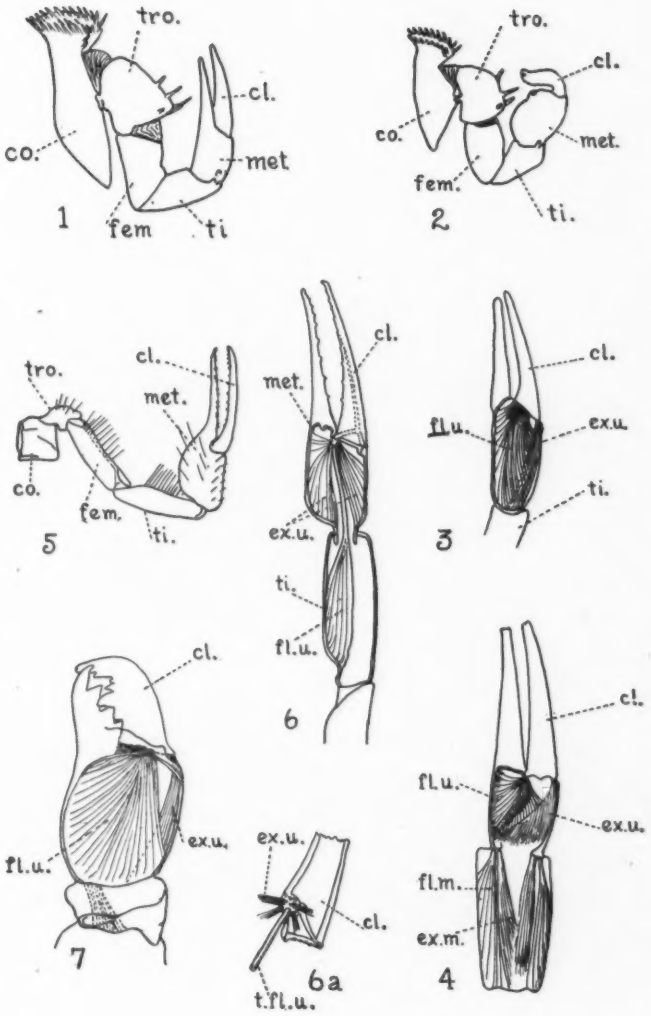
Fig. 23. Photomicrograph from a section of the tip of the palp of a young male Phidippus audax (Hentz) showing claw and palpal organ. (× 130).
Fig. 32. Photomicrograph of a section of the expanded pad of Cleobis stimpsoni, Putnam. (× 130).
Fig. 46. Photomicrograph of a section of the palp of a young male Steatoda borealis (Hentz). (× 30).
Fig. 47. Photomicrograph of a section of the palp of a male Steatoda borealis, Stage II. (× 30).
Fig. 48. Photomicrograph of a section of the palp of a young female Steatoda borealis (Hentz). (× 30).
Fig. 49. Photomicrograph of the tip of the palp shown in Fig. 48. (× 130).
Fig. 50. Photomicrograph of the tip of the palp shown in Fig. 46. (× 130).

PLATE XLII.

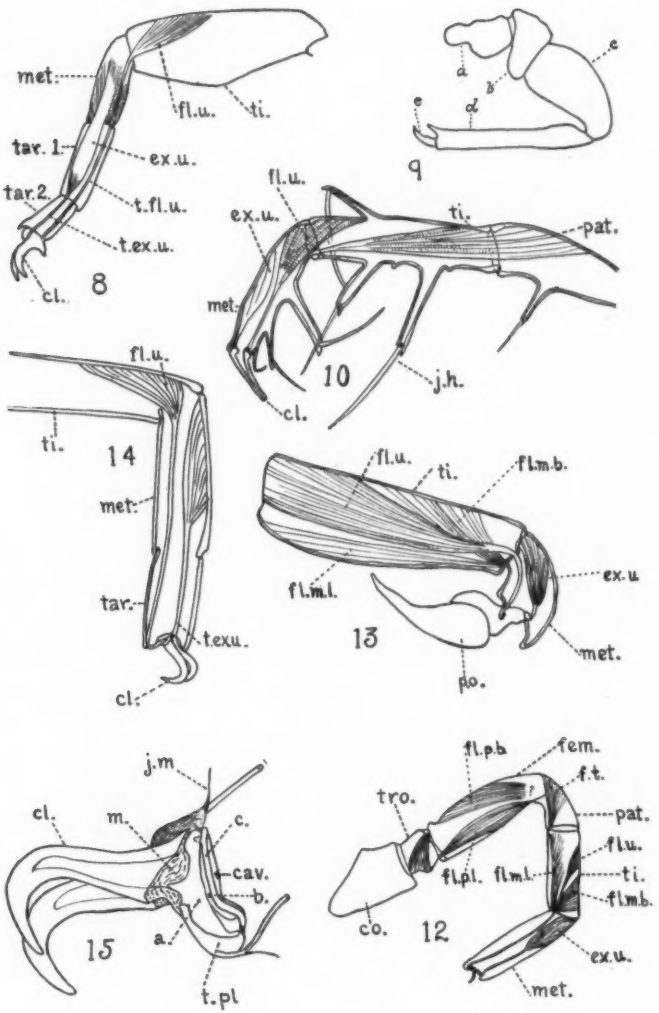
Fig. 51. Photomicrograph of the tip of the section shown in Fig. 50. (× 130).
Fig. 52. Photomicrograph of the tip of a male palp, (Stage I), at a stage of development similar to that shown in Fig. 46. (× 130).
Fig. 53. Photomicrograph of a section of the tip of a male palp of Steatoda borealis, Stage II, b.
Fig. 54. Photomicrograph of a section of the metatarsus of a palp of a young male Steatoda borealis, Stage II, a. (× 130).
Fig. 55. Photomicrograph of a section of the tip of a male palp, Stage III. (× 30).
Fig. 56. Photomicrograph of the fundament of the palpal organ of a male Steatoda borealis, Stage III. (× 130). The orientation of this section is the same as that of Fig. 55.

PLATE XLIII.

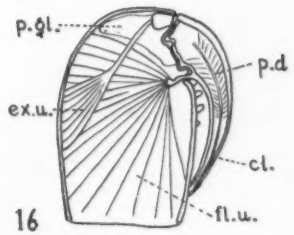
Fig. 57. Photomicrograph of a section of male palp of Steatoda borealis, Stage IV. (× 30).
Fig. 58. Photomicrograph of a section not far from the one shown in Figure 57.
Fig. 59. Photomicrograph of a section of the developing palpal organ shown in Figures 57 and 58, but from another section. (× 130). Orientation the same as in Figure 58.
Fig. 60. Photomicrograph of a section of a male palp of Steatoda borealis, Stage IVa. (× 30).
Fig. 61. Photomicrograph of a section near the one shown in Figure 60, Stage V.
Fig. 62. Photomicrograph of a section of the palp of a young male, Lycosa nidicola Emerton. (× 30).
Fig. 63. Photomicrograph of the tip of the section shown in Figure 62, to show tendons and base of claw. (× 130).


tro.
cl.
co.
met
1
fem
ti
tro.
cl.
co.
met.
fem.
ti.
2
tro.
cl.
met.
co.
fem.
ti.
5
cl.
met.
ex.u.
ti.
fl.u.
6
cl.
fl.u.
ex.u.
ti.
3
cl.
fl.u.
ex.u.
7
ex.u.
cl.
t.fl.u.
6a
cl.
fl.u.
ex.u.
fl.m.
ex.m.
4

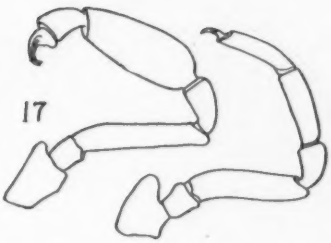
Wm. M. Barrows


met.
fl.u.
ti.
tar. 1.
ex.u.
tar. 2.
t.fl.u.
t.ex.u.
cl.
8
a
b
c
d
e
9
fl.u.
ex.u.
ti.
pat.
met.
10
j.h.
cl.
fl.u.
ti.
14
met.
tar.
t.ex.u.
cl.
fl.u.
ti.
fl.m.b.
fl.m.l.
ex.u
13
met.
ap.
j.m
cl.
m.
c.
cav.
b.
a.
15
t.pl
fl.p.b
fem.
f.t.
tro.
pat.
fl.u.
fl.pl.
fl.m.l.
ti.
fl.m.b.
co.
12
ex.u.
met.

Wm. M. Barrows

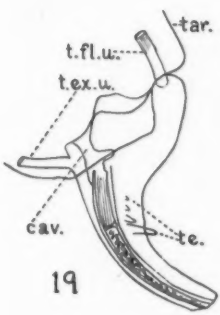


16



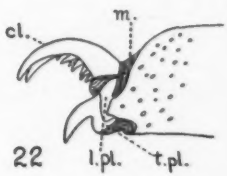
17

18

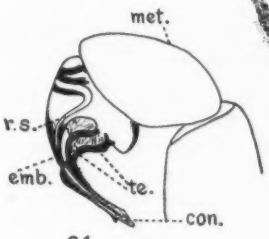


19

20

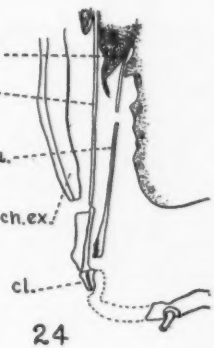


22



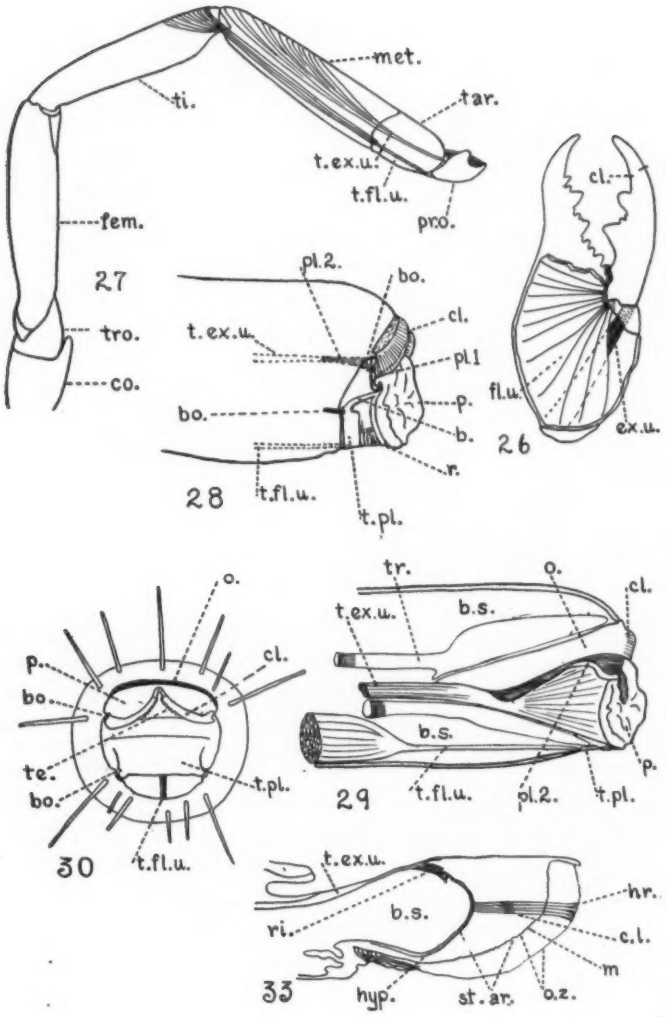
21

25

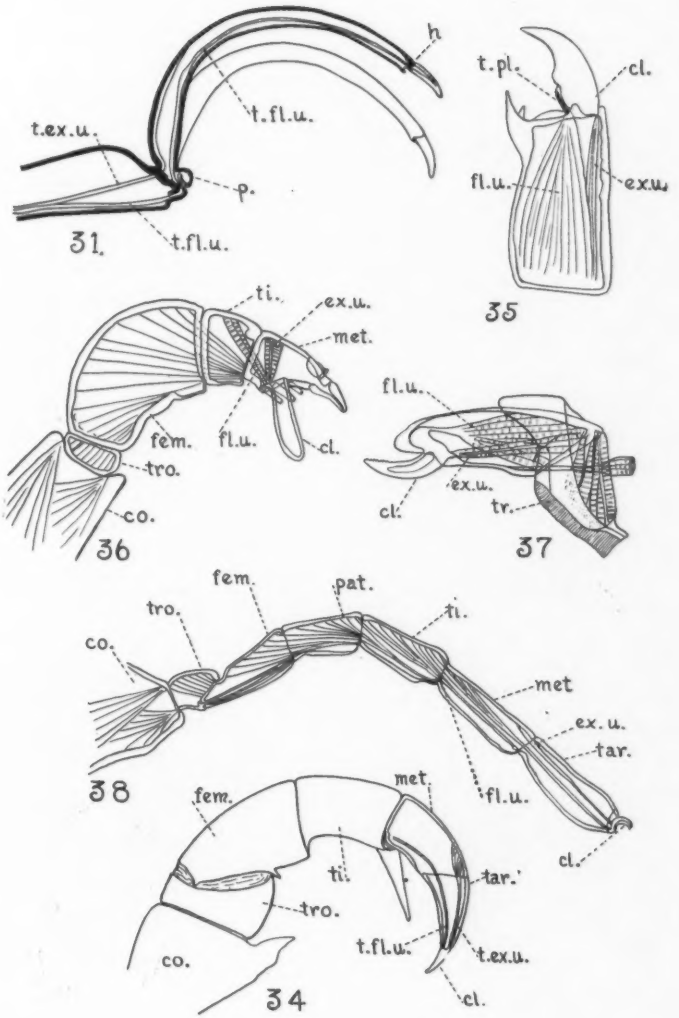


24

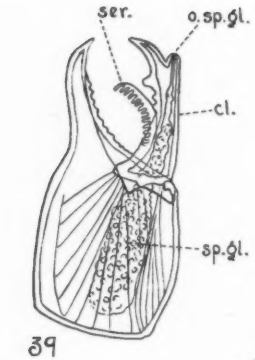
Wm. M. Barrows


met.
ti.
tar.
t.ex.u.
t.fl.u.
pro.
fem.
27
tro.
co.
pl.2.
bo.
cl.
t.ex.u.
pl.1
p.
bo.
b.
r.
28
t.fl.u.
t.pl.
cl.
fl.u.
ex.u.
26
o.
p.
cl.
bo.
te.
bo.
t.pl.
30
t.fl.u.
tr.
o.
cl.
t.ex.u.
b.s.
b.s.
p.
29
t.fl.u.
pl.2.
t.pl.
t.ex.u.
hr.
b.s.
ri.
c.l.
m
33
hyp.
st. ar.
o.z.

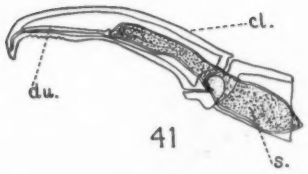
Wm. M. Barrows


h
t.fl.u.
t.ex.u.
p.
t.fl.u.
31.
t.pl.
cl.
fl.u.
ex.u.
35
ti.
ex.u.
met.
fem.
fl.u.
cl.
tro.
co.
36
fl.u.
ex.u.
cl.
tr.
37
fem.
pat.
tro.
ti.
co.
met
ex.u.
tar.
38
fl.u.
cl.
fem.
met
ti.
tar.
tro.
t.fl.u.
t.ex.u.
co.
cl.
34

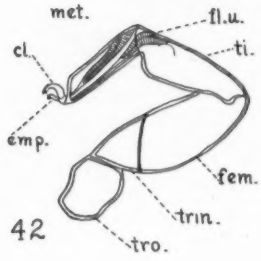
Wm. M. Barrows



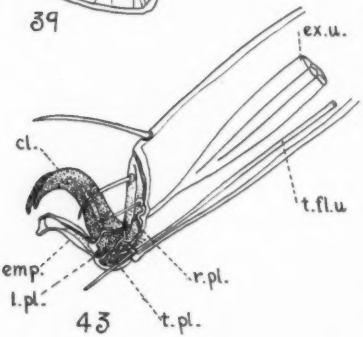
39



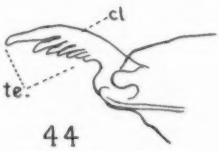
41



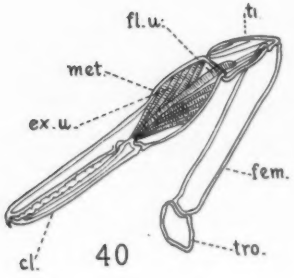
42



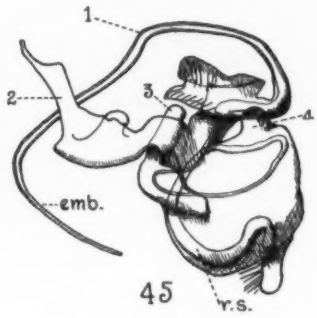
43



44

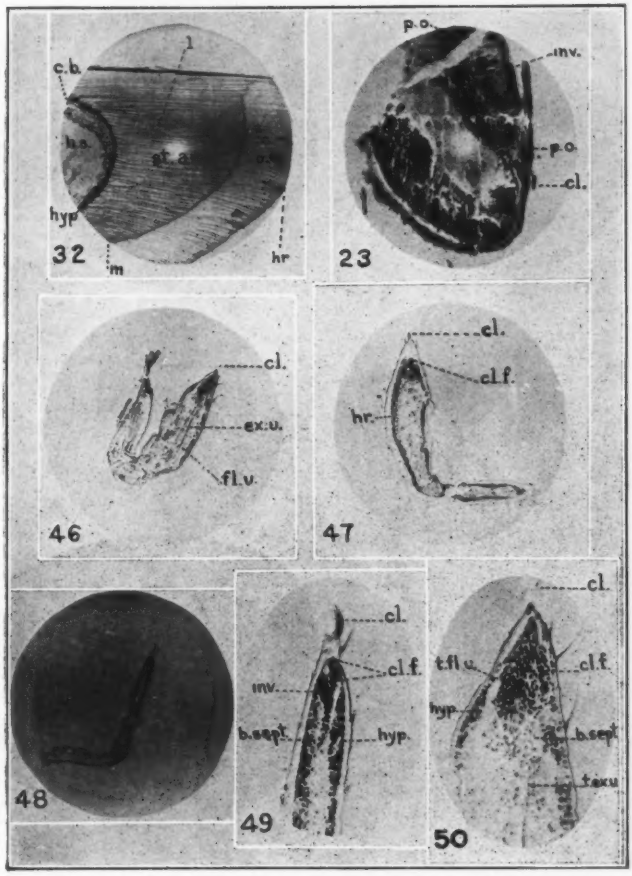


40

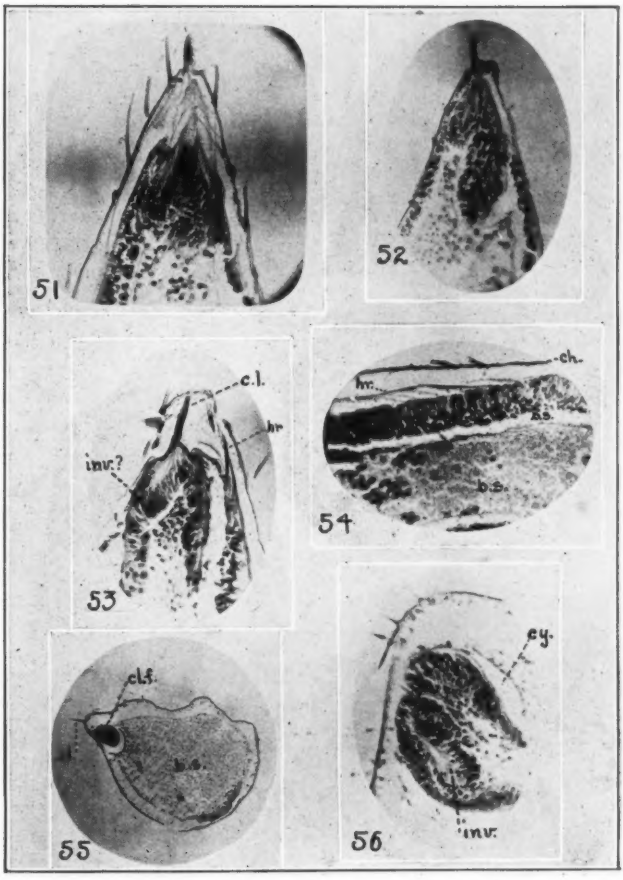


45

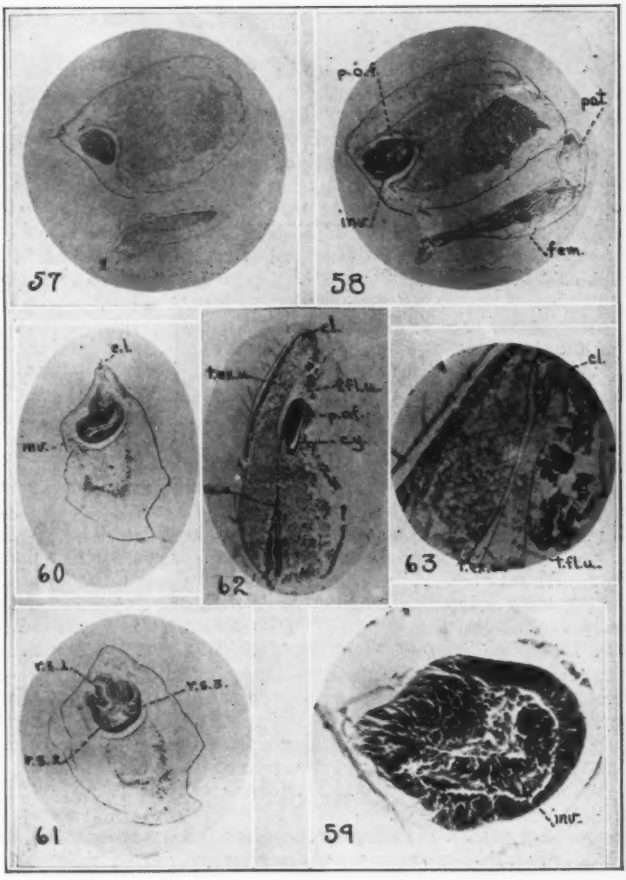
Wm. M. Barrows


c.b.
l.
h.s.
hyp
m
hr
32
p.o.
inv.
p.o.
cl.
23
cl.
ex.u.
fl.u.
46
cl.
cl.f.
hr.
47
48
cl.
cl.f.
inv.
b.sept.
hyp.
49
cl.
t.fl.u.
cl.f.
hyp.
b.sept.
t.ex.u.
50

Wm. M. Barrows



Wm. M. Barrows


57
58
p.o.f.
pat
inv.
fem.
60
e.l
inv.
62
cl
t.fl.u.
p.o.f.
cy
63
cl.
t.fl.u.
61
v.s.1.
v.s.2.
v.s.3.
59
inv.

Wm. M. Barrows

TWO NEW SPECIES OF THE GENUS LACHNUS

C. P. Gillette and M. A. Palmer.

Lachnus juniperensis n. sp.

Alate Viviparous Female (Plate XLIV, 1, and Text Figs., 6 and 7). Described from two examples taken on *Juniperus sibirica*, Aug. 20, 1924, in Pingree Park, Colo., by C. R. Crosby.

Color, abdomen light greenish brown, head and thorax black, cornicles black, covered with very light pulverulence most noticeable about sutures of thorax, intersegmental lines and lateral patches anterior and posterior to cornicles on abdomen; legs pale yellow with almost entire femora, knees, tarsi, distal ends of tibiæ, comprising one-half of metathoracic tibiæ black; antennæ pale yellow with entire 1st, 2d and 6th and tips of 3d, 4th and 5th joints black; stigma costa and subcostal vein light dusky brown, also smoky brown area at distal end of radial sector and a larger area at distal end of 2d discoidal vein.

Measurements: body, 4 mm. x 1.9 mm.; wing, 5.2mm; hind tibia, 3.2 mm.; hind tarsus, .50 mm.; antenna, 1.75 mm., joints as follows: III, .56–.60 mm.; IV, .27 mm.; V, .30–.34 mm.; VI, .23+.03 mm.; beak attaining middle of abdomen; cornicles about .40 mm. in diameter at base of cone.

Secondary sensoria convex, arranged as follows: III, 1; IV, 1; V, 1; unguis short conical. Hairs on outer side of hind tibia numerous, rather spine-like, set at slightly more than 45 degrees, attaining length of .13 mm., exceeding diameter of tibia by about one-half; hairs on 3d joint of antenna attaining length of .12 mm., or three times diameter of joint, hairs on body and cornicles similar to those on antennæ, fore wing with media only once branched, i. e., with only two forks, faint.

Apterous Oviparous Female (Plate XLIV, 3, and Text Figs., 8, 9 and 10). Described from ten examples taken Aug. 24, 1921, on underside of twigs of *Juniperus sibirica* in Estes Park, Colorado.

Color, medium dark brown throughout with cornicles black, heavy powdery secretion on 7th and 8th abdominal segments; legs black or blackish throughout; antennæ, dark excepting basal half of 3d joint.

Measurements: body, 3.5 by 2 mm.; hind tibia, 1.6 to 2 mm.; hind tarsus, .33 mm.; antennæ, 1.3 mm.; joints as follows: III, .37–.42 mm.; IV, .17–.20 mm.; V, .23–.26 mm.; VI, .13–.17 mm.+.03 mm.; beak attaining about middle of abdomen, terminal joints rather stout, measuring .21, .18 and .08 mm., respectively, cornicles, .25–.40 mm., in diameter at base of cone.

Secondary sensoria strongly convex, arranged as follows: III, 1; IV, 1; V, 1. Unguis short, conical. Hairs on outer side of hind tibia numerous, rather fine, set at angle of 45 to 55 degrees, attaining length of .13 mm., almost once and a half diameter of tibia; hairs on 3d joint of antenna similar to those on tibia but slightly shorter, the longest

about three times diameter of joint; hairs on body and cornicles similar to those on antennæ. Hind tibiæ very slightly swollen and with convex sensoria scattered throughout entire length.

Egg (Plate XLIV, 2) described from numerous eggs taken with oviparous females described above. Size, 1.4 mm. by .6 mm., black without powder.

Collections were made as follows, on twigs of *Juniperus sibirica:*

Alate Viviparous Female—Pingree Park, Colo., Aug. 20, 1924, by C. R. Crosby.

Apterous Oviparous Female—Estes Park, Colo., Aug. 24, 1921, by M. A. Palmer.

This species is distinguished from *Lachnus rubicundus* Wilson and other similar species by differences listed below:

TABLE I.

Species	Size	Sensoria	Media	Smoky on Wing	Alate Hind Tibia	Unguis
rubicundus..	3.5mm. apt.	III, 5–7; IV, 1–2 (alate) III, 0; IV, 0 (apt.)	3 forks	not mentioned	1.9 mm.	
juniperi.....	3.2 mm. alate 3.6 mm. apt.	III, 11 (alate)	3 forks	not mentioned		long
junipivora...	2.9 mm. alate	III, 7; IV, 1–2, V, 2 (alate)	not mentioned	not mentioned	2.99 mm.	
juniperensis.	3.5 mm. apt. 4mm. alate	III, 1; IV, 1; V, 1 (alate) III, 1; IV, 1; V, 1 (apt.)	Two Branches	2 dusky spots	3 mm.	short

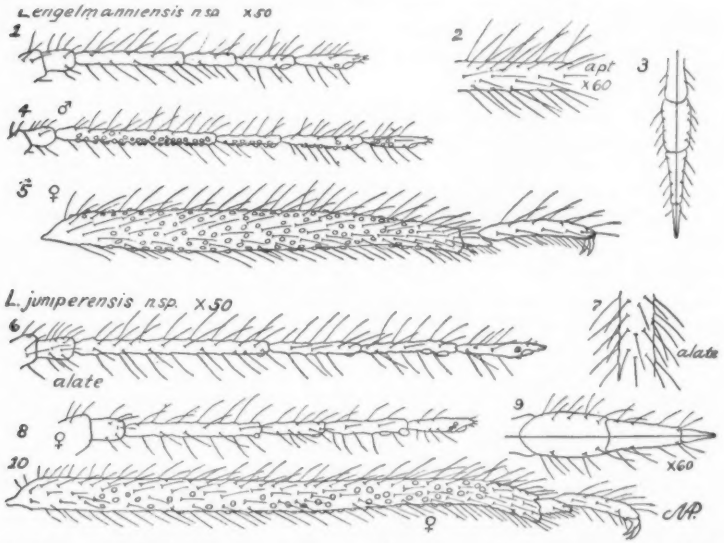
Lachnus engelmanniensis n sp.

Apterous Viviparous Female (Plate XLIV, 4, and Text Figs., 1, 2 and 3). Described from four examples taken Aug. 20, 1924, on bark of young twigs of *Picea engelmanni* in Pingree Park, Colo., by F. C. Hottes.

Color: pinkish buff to cinnamon buff (Ridgway) with two longitudinal rows of blackish areas extending from prothorax to tip of abdomen, confluent on 7th and 8th abdominal segments, dorsum with four rows of black dots, dorso-laterally placed; powder very slight evident only on intersegmental lines; cornicles hardly darker than body; legs concolorous with body, with only tarsi and extreme tips of

all tibiæ black to blackish; femora without dusky coloring; antennæ pale, with 1st and 2d joints darker and tips of 4th and 5th and entire 6th joints dusky.

Measurements: body, 3 mm. by 2 mm.; length of hind tibia 1.2 mm.; hind tarsus .35 mm.; antenna, 1 mm.; joints as follows: III, .24–.33 mm.; IV, .10–.16 mm.; V, .13–.18 mm.; VI, .15–.17+.03mm; cornicles moderate in size, about .30 mm. in diameter at base of cone; beak attaining 1st and 2d segments of abdomen, terminal joints measuring .16, .15 and .10 mm., respectively.



Lachnus engelmanniensis n. sp. 1, antenna of apterous viviparous female; 2, middle of hind tibia of same; 3, terminal joints of beak of same; 4, antenna of male; 5, hind tibia of oviparous female.

Lachnus juniperensis n. sp. 6, antenna of alate viviparous female; 7, middle of hind tibia of alate viviparous female; 8, antenna of oviparous female; 9, terminal joints of beak of same; 10 hind tibia of same.

Secondary sensoria none, unguis short and blunt conical. Hairs on outside of hind tibiæ numerous, nearly erect, moderately fine, long, longest .15 mm., one and a half times diameter of tibia; hairs on 3d joint of antennæ similar to those on tibia, attaining .10 mm. in length, twice the diameter of joint; hairs on body same as on antenna.

Apterous Oviparous Female (Plate XLIV, 7, and Text Fig., 5). Described from five examples taken October 21, 1922, on bark of twigs of *Picea engelmanni* south of Long's Peak, Estes Park, Colo., and nine examples reared as progeny of above described apterous viviparous female.

Color: cinnamon brown (Ridgway) throughout, with a pair of longitudinal dusky lines on dorsum, very slight covering of wax, showing only on intersegmental lines, no powdery tip on abdomen as is usual in oviparous female, even venter without powder; cornicles but slightly darker than body; legs and antennæ as in viviparous female described above.

Measurements: body, 3 mm. by 1.7 mm.; hind tibia, 1.3 mm., hind tarsus, .4 mm.; antennal characters and hairs as in viviparous female. Hind tibia swollen and liberally sprinkled with small, slightly raised sensoria.

Egg (Plate XLIV, 8). Described from numerous eggs taken with oviparous females above described. Color when first laid, shining honey yellow, turning to polished black in a few days, no powdery covering. Deposited singly, lengthwise on needles.

Alate Male: Described from eight examples reared from young taken Aug. 24, 1924, on *Picea engelmanni* in Pingree Park, Colo., alt. 9000, by F. C. Hottes and M. A. Palmer.

Young: (Plate XLIV, 5). Color: light apple green with a pair of longitudinal areas of darker apple green beginning on metathorax and extending to 8th segment, head slightly dusky; legs and antennæ pale with tarsi, tips of tibiæ and antennæ dusky to black, cornicles hardly darker than abdomen; eyes dark red; wing pads in pupa black, with very slight pulverulence.

Adult: (Plate XLIV, 6, and Plate XLV, 4).

Color: abdomen, apple green with a pair of darker green areas on each segment, confluent on 8th, head and thorax, dark brown to black; legs pale honey yellow with tarsi and extreme tips of all tibiæ black or blackish; antennæ same color as legs with entire 1st, 2d and 6th, and tips of 3d, 4th, and 5th dusky; eyes dark brown; stigma, costal and stigmal vein yellowish brown, costal cell smoky, especially in distal half.

Measurements: body, 2.5 mm. by .9 mm.; wing, 3.8 mm.–4 mm. in length; hind tibia, 1.35 mm.; hind tarsi, .40 mm.; antenna, 1.25 mm.; joints as follows: III, .42–.49 mm.; IV, .20–.24 mm.; V, .20–.25 mm.; VI, .15–.19+.03 mm.; beak attaining anterior portion of abdomen, terminal joints slender, measuring .16, .15 and .10 mm., respectively.

Secondary sensoria as follows: III, 36; IV, 10; V, 5; unguis short conical. Hairs on outer edge of hind tibia fine, numerous, erect, .15 to .19 mm. in length, or three times diameter of tibia; hairs on 3d joint of antenna attaining .10 mm., or twice diameter of joint; hairs on body numerous and about the same as on hind tibia; hairs on cornicle as on antenna; fore wing with media only once branched, i. e., with two forks, only faint; hind wing with two cross veins.

Collections were taken as follows, all on bark of tender twigs of *Picea engelmanni:*

Apterous Viviparous Female: Laramie-Poudre Tunnel, Colo., Aug. 12, 1922, M. A. Palmer; Grand Mesa, Colo., July 9, 1923, C. A. Bjurman; Pingree Park, Colo., Aug. 20, 1924, F. C. Hottes.

Oviparous Female: Wild Basin, south of Long's Peak, Colo., Oct. 21, 1922, M. A. Palmer; Pingree Park, Colo., Sept. 9, 1924,* M. A. Palmer.

Male: Pingree Park, Colo., Sept. 3, 1924,* M. A. Palmer.

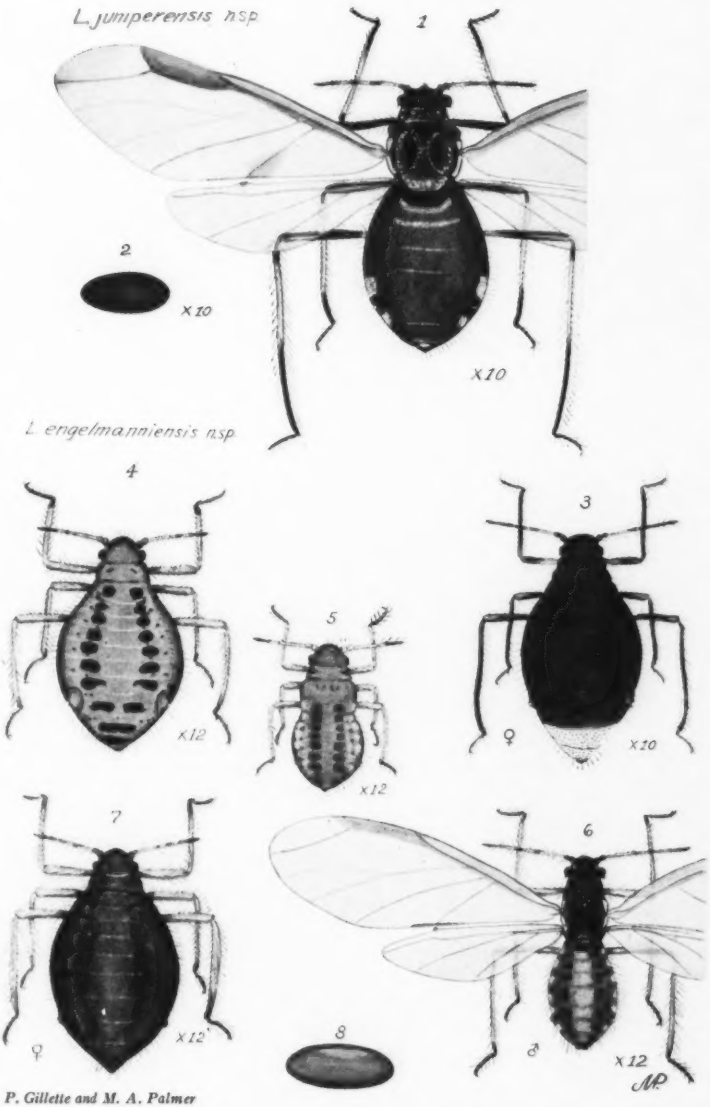
This species is rather rare and inconspicuous, occurring rather scattered instead of in crowded colonies.

This species seems to come very close to the following species on *Picea*, but differs in the respects mentioned below. It may later be found to be a variety or even synonymous with one of these, but there does not seem to be sufficient evidence at present to so determine it as the differences noted are quite decided.

TABLE II.

Species	Powder	Media	Legs	Hairs	Sensoria	Male
L. braggii Gill.	Heavy	Twice forked			Often on 4th and 5th apt.	Brown
L. farinosus Chol'd	Heavy	Twice forked				
L. hyalinus Koch	"Long wooly"	Twice forked				
L. macrocephalus Buck't.	Short wooly cotton filaments	Twice forked		Short		
L. caudelli Wil.			Tibiæ dark, femora dark at tips			
L. picercola Cholod.			One-half hind tibia dark			
L. pinicola Kalt.		Twice forked	Dusky to black			
L. glehnus Ess.	Heavy	Twice forked				
L. engelmanniensis	Very slight not even tip of abdomen of ovip.	Once forked	Tips of tibiae only, dark	Long	None	Green

*Reared in insectary from sexuparæ taken August 20, 1924, by F. C. Hottes.



C. P. Gillette and M. A. Palmer

Lachnus juniperensis n. sp. 1, alate viviparous female; 2, egg; 3, oviparous female.
Lachnus engelmanniensis n. sp. 4, apterous viviparous female; 5, pupa of male; 6, adult male; 7, oviparous female; 8, egg.

ASSOCIATIVE MEMORY IN THE LARVAE OF ANAX JUNIUS

CYRIL E. ABBOTT.

INTRODUCTION.

In his account of the senses of insects, Forel (4) describes the actions of a certain water-beetle as being the result of association. Lubbock (5) and Bouvier (2) give similar accounts of habit-formation. Sondheim (7) kept a dragon-fly larva which learned to come to her for food. These experiences naturally raise the question as to what extent associative processes will modify the behavior of insects. Would it be possible, for instance, to reverse the negative reaction to light which Riley (6) found dragon-fly larvae to possess? The following experiments were conducted with the purpose of discovering to what extent feeding and fear may produce habit, and whether they can overcome instinctive reactions.

Anax larvae live well under artificial conditions, and their behavior is not complicated by the ramifications of sex. Their psychology is, however, far from simple, and it is strange that they have been the subjects of so little research.

RESULTS.

EXPERIMENT I.

Each insect was put into a finger-bowl, and a record kept of its behavior. One trial was made every day or every other day. The words, "left water," mean that the animal partially or entirely emerged from the water at the approach of food.

1. Left water after eleven trials.
2. " " " nine "
3. " " " sixteen "
4. " " " ten "
5. " " " seven "

EXPERIMENT II.

Aquaria 4 x 4 x 18 inches were substituted for the finger-bowls. A 500-watt nitrogen bulb in a metal box, one ond of which was open, was used as a source of illumination. It was placed with the open end

successively over the end of each tank, and an effort made to lead the insects into the center of illumination with food.

1. Entered light after twelve trials.
2. " " " twelve "
3. " " " nine "
4. Would not enter light.
5. Entered light after ten trials.
6. Entered light after ten trials. In one instance this larva entered the light before it was fed.
7. Entered light after nine trials.
8. " " " " "
9. " " " " " In one instance this larva entered the light before it was fed.
10. Entered light after thirteen trials.
11. " " " " "

EXPERIMENT III.

The apparatus used was the same as that used in Experiment II. Whenever the insects entered the shaded areas, they were pushed into the sand or the water near them was stirred violently. This was repeated until they remained in the light.

1. Entered light after five days.
2. " " " four "
3. " " " our "
4. " " " four "
5. " " " five "
6. " " " three "
7. " " " four "
8. " " " four "

DISCUSSION.

As a whole, the larvae which were fed at regular intervals passed through three definite periods of behavior. The first was a period of indifference characterized by failure of the insect to respond to any stimulus. The second stage was one of slight motor responses, such as extension of the labium and movements of the head. The third period was marked by distinct movements of the head, by crawling, by swimming, etc. The insects would sometimes approach food from a considerable distance, would follow it around the vessel, and often noted the movements of the experimenter by turning their heads.

Individuals varied much in their behavior. Some were much quicker than others, and learned more readily than their fellows. A few allowed food to be placed in their mouths without moving their masks. This individual variation, as

well as the fact that the reactions were often modified by satiety or fear, indicates that the responses were not automatic. Although all larvae which were kept in the laboratory soon overcame their fear of the strange surroundings, only those used in the experiments seemed to particularly respond to external stimuli.

While Demoll (3) has studied, to some extent, the senses of these insects, much remains to be done before we possess a definite knowledge of their reactions. Anax noticed dark objects more readily than those of light color, and a moving object more easily than one that was static. They reacted to small objects at a distance of a few inches, and to larger masses at a distance of several feet. The larvae appeared to see quite as well in subdued light as under intense illumination. They snapped at pinheads and other inedible objects; generally indicating that they are unable to distinguish, at a distance, the chemical nature of a substance. It will be necessary to have more work like that of Baldus (1) before the nervous physiology of these animals can be fully understood.

Anax larvae avoid intense light. When their habitat is partially illuminated, they are invariably found in the shaded areas. If an intense light is turned on them they will avoid it by crawling or swimming away. Individuals differ in their intolerance to light; some leave their places as soon as rays strike them, while others may remain in the lighted area for several seconds or even a minute. Some move in a leisurely manner, while others make violent efforts to escape. Since a 500 watt bulb gives off considerable heat, an experiment was made to determine to what extent temperature could have influenced the larvae. Warm water was introduced into a pan containing controls, but the animals gave no evidence of being affected by a temperature below that fatal to life.

The negative light reaction is not an orienting reaction. None of the larvae behaved consistently under illumination. In subdued light they rested at every possible angle to the direction of the rays. In avoiding intense light they sometimes backed away from the source of illumination, but more often they "swam" by ejecting water from the rectum.

Insects which were fed at regular and frequent intervals in or near light behaved quite differently from those under more normal conditions. At first they passed through the usual

stage of indifference. If they could be induced to follow food to the light, they either took it before they reached the center of illumination, or returned to the darker portions of the tank without feeding. Gradually they learned to enter the light when they saw food there. The light was not always in the same ends of the tanks, so that its location could have had little to do with the behavior of the insects. Continued exposure to intense light at regular intervals tended to make the larvae indifferent to this stimulus.

Larvae react even more readily to fear than to food. After being stirred about and pushed into the sand a few times, the animals took refuge in the light. At first they continued to return to the darker ends of the aquaria, but after from ten to fifty such maltreatments, they invariably sought the light. The larvae at all times paid more attention to the movements of surrounding objects than they did to the distribution of light.

Conclusions.

Anax larvae pass through three stages when fed regularly and at frequent intervals; these may be characterized by indifference, slight recognition, and intense activity. They form associations in connection with feeding and with maltreatment. Both fear and food reactions may overcome the instinctive aversion of these insects for intense light. It must be admitted, however, that light appears to be a secondary factor in the lives of these animals. Although they overcome their negative response to light, their actions at all times indicated an indifference to this stimulus when more vital factors were present. Their behavior was chiefly dependent upon what they saw moving in or near their habitat, and only secondarily did they associate light with these movements.

BIBLIOGRAPHY.

1. **Baldus, E.** Untersuchungen uber Bau und Funkton des Gehirnes der Larve und Imago von Libellen. Zeit. Wiss. Zool. CXXI, 1923, p. 37.
2. **Bouvier, E. L.** (trans. L. O. Howard). Psychic Life of Insects. 1912.
3. **Demoll, R.** Gelegentliche Beobachtungen an Libellen. Biol. Centbl. XXXIII, 1913. p. 727.
4. **Forel, A.** (trans. Macleod Yearsley). The Senses of Insects. 1908.
5. **Lubbock, Sir J.** Senses, Instincts, and Intelligence of Animals. London, 1888.
6. **Riley, C. F. C.** Observations on the Ecology of Dragon-fly Nymphs. Ann. Entom. Soc. Am. V, 1912. p. 273.
7. **Sondheim, M.** Wahrenehmungsvermogen einer Libellenlarve. Biol. Centbl. XXI, 1901. p. 317.

SOME REMARKS ON THE PERIPHERAL NERVOUS SYSTEM OF INSECTS.

WILLIAM A. HILTON,
Department of Zoology, Pomona College, Claremont, California.

In 1902 and 1924 I determined the endings of nerve cells in the body-wall of various insects. At this time I wish to further extend this record.

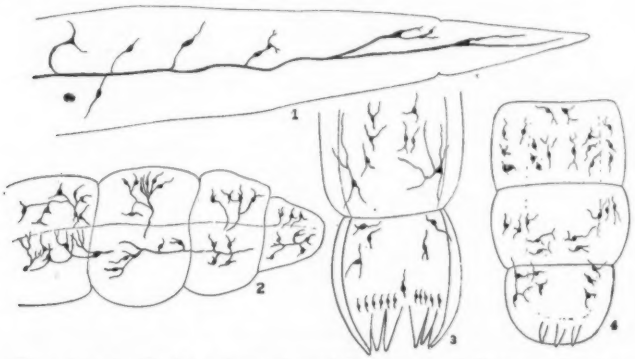
For a number of years as opportunity offered, I have investigated the nervous system of arthropods and have come to the conclusion that the termination of nerves in the bases of hollow hairs is quite characteristic. Practically all true hairs have bipolar nerve cells at their bases and from these, fine strands run into the bases of the setae. When anything like a perfect stain is obtained all the hairs have this interesting type of termination. In some cases the hairs are minute, in others they are large. The nerve cells are large or small to correspond to the end organs. Spines or knobs are not homologous with these hollow hairs and as a rule have other types of nerve supply. Compound or grouped hairs have the usual type of nerve termination. Even scales such as we find replacing hairs in Lepidoptera and some other groups, have shown the same kind of bipolar cell.

Holmgrin ('96) and Hilton (1902), noticed certain multipolar cells in lepidopterous larvae. These seemed associated with the nerve cells in a rather loose manner. These authors were somewhat doubtful about the cells being true nerve elements, but because of later studies of other forms, I have been inclined to consider them true nerve cells, possibly representing the primitive nerve-net well known in other groups.

In certain dipterous larvae, such as those of the snipe-fly, I have found all gradations between cells terminating in hairs and freely in the skin. Some of these terminal cells are bipolar, some are multipolar. In these and other larvae there are great areas where there are no hairs. In such places the terminations are not so abundant as in certain hairy larvae, yet nerve terminations do occur, sometimes in the form of a simple plexus. Zwarzin, in dragon-fly nymphs shows many terminations in hairs and also a number of places where bipolar and other cells are found ending with no hairs near.

Besides the peripheral networks involving nerve cells, there are networks of fibers in the body-wall of insects that are merely the peripheral anastomoses of fibers from one or more rather distant cells.

Somatic receptor cells from striated muscle fibers were demonstrated in Dendroides. These were bipolar cells of small size. Sometimes a single cell, sometimes a small group, was found with its rather simple terminations in the muscle fibers.



Figs. 1 to 4. Surface views of caudal segments of dipterous larvae.
Fig. 1. Side view of the caudal end of a snipe fly larva. Figs. 2–4, crane-fly larvae caudal end; 2, lateral view; 3, ventral; 4, dorsal side. In all these figures nerve elements shown in black.

Visceral receptor cells are described in the digestive tract of a beetle larva by Orlov in 1924. These were bipolar or tripolar cells, with terminations in muscles sometimes simple, sometimes more or less complex. In a few cases the terminals were wound about the muscle fibers simulating the type found in vertebrates.

Somatic effector cells of arthropods are located in the central nervous system. The cells differ in size, form and location. Some of them are simple and direct. Some of them send their motor fibers out the same side of the ganglion, but many of them cross to the opposite side. The motor trunks probably differ greatly in different insects and in different ganglia of the same insect, although thoracic ganglia in the same form agree quite well as do abdominal ganglia with each

other. In lower segments of insects the motor branches are rather more simple and perhaps somewhat more restricted than the sensory, because there are fewer muscle fibers in any one segment as a rule than sensory hairs. The peripheral

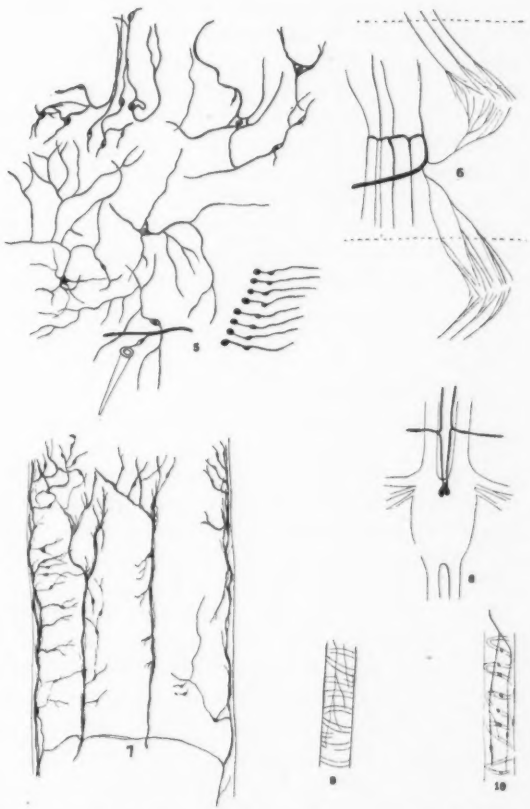


Fig. 5. Nerve cells from the skin of snipe-fly larva. The bipolar cells at the right end in small chitinous knobs, not in hairs.

Fig. 6. Large lateral muscle nerve with branches to the heart; one segment is shown with the chief muscular branches, one of which is a heart branch. Other nerves from other segments are shown in relation to the heart.

Fig. 7. Superficial and deep nerve plexus of the intestine of Dendroides shown in optical section.

Fig. 8. Outline of a ventral ganglion showing central nerves with their lateral branches. Dendroides.

Figs. 9 and 10. Nerve supply to Malpighian tubules. Dendroides.

nerve endings in muscle are similar to those described in vertebrates. It is quite probable that several neurones combine to supply a single muscle fiber. This certainly seems to be true in the beetle larva Dendroides, where at least ten cells contribute to a single muscle fiber.

At least some of the muscles of the heart are somatic rather than visceral for the following reasons:

1. Because the muscles are striated.

2. Because the muscle fibers are supplied from general muscle nerve trunks springing from each ventral ganglion. At least this is the supply in Dendroides. The delicate fibers to the heart are not supplied by a single segment, but part of the nerves arise from the ganglion above in the abdominal region. This is the only case where a nerve from a ventral ganglion in Dendroides supplies parts outside its own segment. Of course this does not count the sympathetic system which is not segmental.

In the work of Zwarzin, 1911, the heart muscles of dragon-fly nymphs are described. He recognizes nerves from the ventral ganglia to the heart muscles and also sensory and possibly other nerves and cells connected with the sympathetic system and its ganglia.

The visceral system has been more or less completely described in a number of invertebrates, but especially in annelids and arthropods. In insects it is often figured. It consists of a series of ganglia more or less connected with the head region and elaborated into nerve centers and nerves associated with the digestive tube. In the larva Dendroides there is a well developed visceral system. The cephalic ganglia were not determined, but the intestinal system was found to have both a superficial and a deep plexus. There was some indication of bipolar and tripolar nerve cells in various places. Some of these were probably visceral sense cells. The visceral motor cells were perhaps located in the visceral ganglia. There were communications between the superficial and deep plexus.

Movements of Malpighian tubules have been noted from time to time by investigators of insect anatomy. The general opinion has been that these movements were due to contractions of the gland cells of the tubules, but methylene blue stain demonstrates a delicate spiral or ring of muscle fibers. In the same preparations where the muscle fibers are found, fine nerve

fibers may be seen running to these muscles. In some cases the fibers are without cells and are perhaps motor in function, in other specimens small nerve cells are shown on the minute nerves. These fibers are derived from the superficial plexus of the intestine.

Zwarzin, 1924, considers the median nerves which we have in many species of insects. These have been spoken of as being visceral nerves, but Zwarzin is not of this opinion. In many insects these nerves run out to the spiracles and that was the distribution of them that I found in Dendroides. In some forms these nerves are entirely medial and in certain cases they seem to be represented by lateral nerves from the connectives between the ganglia. Such last is the condition of their arrangement in some centipedes as well as in some other arthropods. The condition in Dendroides is somewhat intermediate as the nerves are not entirely medial for all of their distance and the two lateral parts retain their identity and appear like two nerves between the connectives instead of a single fused strand with branches on each side. It is also evident that each lateral branch receives contributions of fibers from the ganglia both the cephalic and caudal ganglia at each end of the connectives. As Zwarzin indicates, there are nerve cells in the caudal ganglion below each lateral nerve pair from the median nerve. There are sensory as well as motor fibers in these lateral branches from this medial nerve system. I agree with Zwarzin in considering these lateral spiracle nerves and the median trunk from which they spring, parts of the somatic and not parts of the visceral system.

Conclusions.

1. Most sensory endings in the body-wall of insects are in hollow hairs by means of bipolar sense cells.
2. There are some nerve terminations in the body-wall of insects in knobs or spines or just at the surface and these are bipolar or multipolar cells.
3. In addition to the usual bipolar sense cells at the surface there may be a network of fibers or a nerve-net of multipolar cells more or less associated with the bipolar cells. This, however, is not always present.
4. Bipolar cells which terminate in skeletal or body musculature evidently serve the muscular sense.

5. Tripolar or bipolar cells probably serve the visceral senses in the digestive tract.

6. The visceral motor cells are probably located in the visceral ganglia.

7. The intestine has a superficial and a deep plexus of fibers and probably cells in the intestine of Dendroides.

8. Motor and possibly sensory branches from the superficial intestinal plexus supply the Malpighian tubes.

9. The heart muscles are supplied from muscular branches of the abdominal ganglia.

10. The medial nerve system is not a visceral complex. Its fibers may come from ganglia both above and below to supply the region of the spiracle on each side.

BIBLIOGRAPHY.

Hilton, W. A. 1914. Jour. comp. neur. v. 36, pp. 299–308.
Orlov, J. 1924. Zeit. f. wiss. Zool. Bd. 122.
Zwarzin, A. 1911. Taf. 22–24, pp. 481–510. Zeit. f. wiss. Zool. Bd. 97.
1912. pp. 97–115. Zeit. f. wiss. Zool.
—— 1924. Zeit. f. wiss. Zool. Bd. 122, pp. 323–424.

INDEX TO VOLUME XVIII.

Abbott, C. E., Article by, 533.
Acarapis woodi, 35.
Acari, 501.
Aclerda, Review of, 432.
Aclerda ariditatis, 436.
  attenuata, 436.
  biwakoensis, 440.
  berlesii, 437.
  californica, 437.
  digitata, 440.
  distorta, 438.
  holci, 438.
  japonica, 440.
  obscura, 440.
  sacchari, 439.
  sella-hispanica, 440.
  signoreti, 440.
  subterranea, 439.
  tokionis, 439.
Acroglossal buttons, in Hymenoptera, 445.
Agrilus olentangyi, 469.
Alconeura, 334.
  planata, 337.
  rotundata, 335.
  tricolor, 336.
  unipunctata, 335.
  quadrivitata, 334.
Aldrich, J. M., Articles by, 107. 456.
Alexander, C. P., Article by, 341.
Alsopsyche nemoralis, 110.
American Spiders, Descriptions, 313.
Anax, junius, Memory of, 533.
Aptostichus flavipes, 317.
Aquatic Insects, Artificial Fertilization of, 45.
Arachnid Palpal Claw, Modification and Development, 483.
Araneae, 491.
Argyromima mirabilis, 122.
Argyrophylax albinicisa, 129.
Arthrochaeta demoticoides, 139.
Arthropods, Poisonous, 471.
Artificial Fertilization of Aquatic Insects, 45.
Auten, Mary, Article by, 240.

Baerg, W. J., Article by, 571.
Ball, E. D., Article by, 324.
Barber, G. W., Article by, 419.
Barrows, W. M., Article by, 483.
Beamer, R. H., Article by, 479.
Beskia cornuta, 120.
Bibiomima handlirschi, 126.
Bombyliomyia flavipalpis, 458.
Brachybothrium shoemakeri, 318.
Brachybothrium pacificum, 493.
Brauer, Alfred, Article by, 283.
Bruchus Quadrimaculatus, Fabr. Studies on the Embryology, 283.
Buprestidae, Wing Venation of, 251.

Chaetogyne vexans, 116.
Chrysotachina rheinwardtee, 111.
Chaetoprocta tarsalis, 461.
Chaetoprosopa auriceps n. sp., 464.
Champlain, A. B., Article by, 469.
Cicadas Kansas, Oviposition of, 479.
Cotinis, Nitida, Behaviour of the Larvae, 31.
Crampton, G. C., Article by, 49.
Crane-Flies of Mexico, 341.
Centipede, 471.
Centruroides margaritans, 472.
Coleoptera, New North Am., 469.
Corn borer, Response to Light, 419.
Cryptomeigenia setifacies, 458.

DeLong, D. M., Article by, 324.
Dermacentor venustus, 502.
Dicranomyia, 342.
  dampfi, 346.
  filicauda, 345.
  melancera, 345.
  ravida, 343.
  tricornis, 344.
Didea, North American Species, 277.
Didea alnetti, 279.
  coquilletti, 280.
  daphne, 280.
  fasciata, 279.
  intermedia, 280.
  laxa, 278.
  laxa var. syrphoides, 278.
Dikraneura and Its Allies in N. America, 324.
Dikraneura, 324.
Dikraneura abnormis, 328.
  angustata, 328.
  carneola, 329.
  cockerelli, 333.
  cruentata, 331.
  elongata, 327.
  fieberi, 327.
  kunzei, 330.
  maculata, 333.
  mali, 326.
  marginata, 331.
  mera, 332.
  rufula, 329.
  sandersi, 332.
Diptera Muscoid, Types, 107. 456.

Entomology Needs of the World, 100.
Erioptera, 351.
  alticola, 353.
  curta, 354.
  inornatipes, 351.
  ochricauda, 352.
  tridentata, 355.
  unidentata, 355.
Eurypelma californica, 475. 492
Exorista optica, 465.

Forbes, W. T. M., Article by, 22.
Frost, S. W., Article by, 399.
Fulton, B. B., Article by, 363.

Gaedophania atra, 463.
Gaediopsis mexicana, 111.
Genieys, Paul, Article by, 143.
Gillette, C. P., Article by, 526.
Gilmer, P. M., Article by, 203.
Good, H. G., Article by, 251.
Gonia rubens, 114.

Habrobracon breviscornis Wesm., 143.
Hesperioid Genera, Types, 75.
Hilton, W. A., Article by, 537.
Hintze, A. L., Article by, 31.
Howard, L. O., Article by, 1.
Hull, F. M., Article by, 277.
Hungerford, H. B., Article by, 417.
Hymenoptera, Acroglossal buttons in, 445.
Hypothetical Wing, 22.
Hypotachina disparata, 464.

Insects Associated with Spider Nests, 240.
Ivesia, 320.
  tennesseensis, 321.

Knull, J. N., Article by, 469.

Lachnus engelmanniensis, n. sp., 527.
  juniperensis, n. sp., 526.
Lachnomopsis armata, 122.
Lachnus, Two New Species, 526.
Larvae of the Chalcidoidea, Notes on, 384.
Lasiopalpus flavitarsis, 118.
Leaf Mining Habit, 399.
Lepidopterous Larvae, A Comparative Study of the Poison Apparatus, 203.
Leptoda gracilis, 123.
Leptoda thomae, 126.
Lepturges neomexicanus, 470.
Leskiomima tenera, 121.
Limonia obtusistylus, 347.
  elephantomyia alticola, 348.
  gonomyia tuberculata, 349.
Lindsey, A. W., Article by, 75.
Liu, C. L., Article by, 445.
Lycosa nidicola, 510.

Macromeigenia chrysoprocta, 462.
Mallonotum brevicornis, n. sp., 467.
Mallonòtum, n. g., 466.
Masiphya brasiliana, 107.
  confusa, 109.
  confusa townsendi, 110.
Masipoda geminata, 128.
Members, List of, v.
Microchira mexicana, 121.
Miscogaster, 391.
Mites. The Occurrence of, in Tracheal System, 35.
Mochlosoma validum, 116.
Molophilus, 350.
  paucispinosus, 351.
  severus, 350.
Muscoid Diptera Types, 107, 456
Myiomima sarcophagina, 124.
Myiomintho elata, 118.

Nephrotoma dampfi, 358.
Nervous System of Insects, 537.
Notonecta from China, 417.
Notonecta suensoni, 417.

Oecanthus niveus, Variation of, 363.
Opiliones, 490.
Opisthocanthus lepturus, 473. 478

Palmer, M. A., Article by, 526.
Palpigradi, 489.
Paradoria nigra, 454.
Paragedia hedemanni, 463.
Paragymnomma hystris, 457.
Paralispe brasiliana, 113.
Paralucilia fulvipes, 456.
Parexorista inculta, 467.
Parker, H. L., Article by, 384.
Pedipalpi, 500.
Peripheral Nervous System of Insects, 537.
Peteina stylata, 120.
Petrunkevitch, Alex., Article by, 313.
Phasiophan obsoleta, 458.
Phidippus audax, 111. 494. 510
Podothrombium sp., 501.
Poisonous arthropods, 471.
Proceedings Washington Meeting, 131.
Prosopaea insularis, 111.
Psalmopeus pulcher, 478.
Pseudoredtenbacheria brasiliensis, 119.
Pseudoscorpionida, 502.
Pseudoviviania platypoda, 459.
Ptilodexia carolinensis, 114.
Ptilozeuxia brevicornis, 466.
Pyrausta nubialis, 419.
Reinwardtia tachinina, 126.

Ricinulei, 487.

Scolopendra sumichrasti, 471. 478
Scorpions, 472.

Sardiocera valida, 114.
Scorpionidea, 486.
Snowy Tree-Cricket, Physiological Variation, 363.
Selenomyia brevicornis, 459.
Sericopelma communis, 475. 478
Sisyropa vorax, 460.
Solifugae, 495.
Spider Nests, Insects Associated with, 240.
Spiders Palpal Claw, 483.
Steatoda borealis, 506.
Sturmia cubaecola, 129.

Tachina trivittata, 111.
Tarsonemus woodi, 35.
Tarantulas, 474.
Teague, M. M., Article by, 432.
Thompson, W. R., Article by, 384.
Thoracic Sclerites, Phylogenentic Study of, 49.
Thysanomyia fimbriata, 462.
Tibicen aurifera, 480. 481
auletes, 479. 480. 481
dorsata, 479. 480
lyricen, 479. 480. 481
marginalis, 479. 480
pruinosa, 479. 480
resh, 479. 480
Tipula, 356.
azteca, 357.
moctezumae, 356.
Trichodura anceps, 115.
Tricholyga vivida, 468.
Trichophora analis, 130.
Tropidopsis Pyrrhaspis, 125.

Wehrle, L. P., Article by, 35.
Welch, P. S., Article by, 35.
Wiebe, A. H., Article by, 45.
Wulpia aperta, 120.

Xiphosura, 485.